Space Environment Sensor Suite (SESS)

System Requirements Review

SESS Government Advisory Team

07 December 2000

Updated for compliance with the TRD V6 (04 May 2001)

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SESS System Requirements Review

SESS Background

EDR Parameter Clarifications

EDR Category Designations

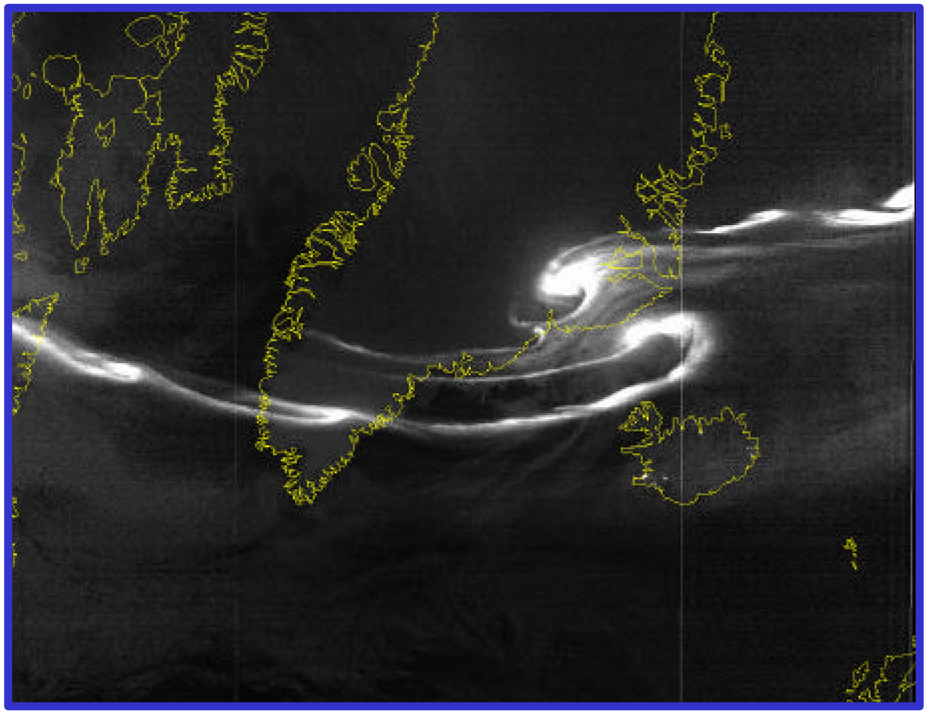
Notional Sensor Suite (H/W & S/W)

Summary

Space Environmental Sensor Suite

Description

Measures the near-Earth space environment in terms of neutral and charged particles, electric and magnetic fields, and optical signatures of aurora. Primary sensor suite for satisfying 14 EDRs.



Functional Specification

Multiple sensors required to measure and process a divergent set of space environmental EDRs

Heritage and Risk Reduction

DMSP - Special Sensors (SSM, SSIES, SSJ, SSUSI, and SSULI)

POES - Space Environment Monitor (SEM)

Top-level User Needs Assessment

USER: DOD	USER NEED
Radar Operations	*Solar noise*, auroral clutter specification
	Range error correction, scintillation
HF Communications	MUF/FOT, PCA event, shortwave fades
Navigation/Satellite Communications	Single frequency GPS accuracy
	Scintillation forecast/specification
Classified	Arbitrary slant path TEC
Altimetry, Single Frequency	Ionospheric corrections for sea surface heights
Satellite Design and Anomaly Analysis	Radiation hazards for manned spaceflight & high flyers
	Long-term representative data sets for satellite design
	Space environment data for anomaly resolution
Space Surveillance	Accurate neutral density forecast/specification

USER: DOC	USER NEED
Satellite Operators	Space environmental parameters affecting satellite ops
Power Companies	*Distribution and intensity of geomagnetic field variations*
NASA	Radiation dose(man) , polar cap boundary, satellite drag
FAA	Ionospheric impacts on communications and navigation
NOAA	Radiation effects on satellite, mag field variations, drag
Ham Radio Operators	Global ionospheric disturbances
Geo-Prospecting	Locations of geomagnetic field variations
Science Community	Space environment effects on experiments, contamination
International Forecast Cntrs (Japan. Australia, etc)	Global situational awareness

USER: NASA	USER NEED
Manned Spaceflight	Radiation Dose
Satellite Lifetimes	Orbital drag forecasts

Note: User need in ***red italics*** are not addressed by NPOESS

IORD Assigns 14 EDRs to SESS

- Auroral Boundary
- Auroral Energy Deposition
- Auroral Imagery
- Electric Field
- Electron Density Profile
- Geomagnetic Field
- In-situ Plasma Fluctuations
- In-situ Plasma Temperature – T_e & T_i
- Ionospheric Scintillation
- Neutral Density Profile
- Medium Energy Charged Particles
- Energetic Ions
- Supra-thermal through Auroral Energy Particles
- Neutral Winds (P^3I)

SESS Requirements Flow

NPOESS Integrated Requirements Document (IORD) 1A - Draft -

IORD

NPOESS Technical Requirements Document (TRD) 5 Appendix D

TRD

SESS Sensor Requirements Document (SRD) - Draft -

SRD

Government Advisory Team (GAT)

Mission

The mission of the SESS GAT is to provide technical support to the IPO in the acquisition of the SESS payload

SPD Direction[1]

- Establish a Government Advisory Team
  - Include expertise from Labs (NDAs may be applicable)
  - Develop SESS to the functional block level including H/W & S/W
- Scrub Requirements for SESS EDRs
  - Review SESS EDR priorities from the Space Environmental Steering Group (SESG) - IPO/ADA document: dated 01SEP98
  - Present JARG / SUAG with reasonable trades to reduce overall SESS complexity / cost

[1]Per 25APR00 Acquisition Decision Brief

GAT Membership

GAT Oversight	Organization	Comments
Maj. Elisa Kang	IPO/ADA	SESS Instrument Manager
Dr. Jim Duda	IPO/TT	Operational Algorithm Team Lead
Dr. Steve Mango	IPO/TT	NPOESS Chief Scientist
Col Frank Hinnant	IPO/ADA	Associate Deputy for Acquisitions

GAT Member	Organization	Area of Expertise
Dr. W. Denig	AFRL	Chair
Dr. O. de la Beaujardiere	AFRL	Electric Field, EDP, Plasma Temp
Dr. Tom Sotirels	APL	Auroral Particles, Magnetometer
Ms. Maureen Garant	MITRE	Requirements
Dr. Dave Evans	SEC	Auroral & High-energy Particles
Dr. Paul Straus	Aerospace	UV sensors, EDP, Scintillation
Maj Markus Sorrellis	IPO	Requirements, User liaison
Ms. Diane Buell	MITRE	Neutral Density Profile, Requirements

EDR Assignments

	Buell	de la Beaujadiere	Evans	Sotirelis	Straus
Auroral Boundary					√
Auroral Energy Deposition			√		
Auroral Imagery					√
Electric Field		√			
Electron Density Profile		√			
Geomagnetic Field				√	
In-situ Plasma Fluctuations					√
In-situ Plasma Temperature		√			
Ionospheric Scintillation					√
Neutral Density Profile	√				
Medium Energy Charged Particles			√		
Energetic Ions			√		
Supra-thermal - Auroral Energy Particles				√	
Neutral Winds (Objective)	√				

SESS System
Requirements Review

- SESS Background
- EDR Parameter Clarifications
- EDR Category Designations
- Notional Sensor Suite (H/W & S/W)
- Summary

EDR Parameter Clarification

The GAT did the following activities:

- ✓ Reviewed the current EDR specifications in accordance with current and future User needs
- ✓ Updated the parameter specifications and recommended updates to the NPOESS IORD, TRD, and SRD documents
- ✓ Provided the quantitative basis for each EDR parameter

EDR 40.8.1
Auroral Boundary

Description: The auroral zone is the area in geospace that is associated with the presence of auroral particle precipitation. The auroral boundary is the set of points that bounds the auroral zone. Both the equatorward and poleward boundaries of the auroral zones are of interest, although the equatorward boundary is of greater priority. Specification of the poleward boundary is left as an objective requirement since its determination is often ambiguous. Auroral precipitation causes enhanced ionization in the E-region which affects HF and radio systems. The threshold requirement for Auroral Boundary is the identification of the auroral boundaries along the satellite path. The objective for the Auroral Boundary is an off-axis (satellite path) mapping of the auroral boundary at all longitudes.

Usage: This EDR supports DOC requirements for global situational awareness of geomagnetic activity. DOD also requires the boundary for situational awareness, with particular application to high latitude radar systems where the occurrence of clutter is correlated with the boundary location. Auroral activity can also affect HF communications systems. In addition, the operational DOD ionosphere specification model uses both boundaries as key inputs.

EDR 40.8.1
Auroral Boundary

		Threshold	Objective
40.8.1-1	a. Horizontal Reporting Interval	50 km	10 km
40.8.1-2	b. Horizontal Coverage	>30º Latitude, N/S	Global
40.8.1-3	c. Measurement Range	>30º Latitude, N/S	Global
40.8.1-4	d. Measurement Uncertainty	50 km	10 km
40.8.1-5	e. Reporting Frequency	Twice per orbit	Four times per orbit
40.8.1-6	f. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.1
Auroral Boundary

Paragraph No.	40.8.1-1
Parameter	a. Horizontal Reporting Interval

Threshold	50 km
Clarification	The requirement for Horizontal Reporting Interval is driven by the needs of two operational user products. For both products, a reporting interval of 50 km results in improved products supporting HF Comm and Navigation. In the near term, the boundaries specified with this level of accuracy will be required as a key input to a model of high-latitude ionospheric scintillation. This model will also be used by surveillance radar operators. Regions of auroral clutter affecting radar systems are typically several hundred km in size. Techniques for addressing objectives in specifying or mapping the boundary at points along the auroral oval should use a horizontal reporting interval commensurate with the above.
Objective	10 km
Clarification	Provides a finer specification of details in the structure of the boundary that may be useful for future ionospheric modeling efforts.

EDR 40.8.1
Auroral Boundary

Paragraph No.	40.8.1-2
Parameter	b. Horizontal Coverage

Threshold	>30º Latitude, N/S
Clarification	This ensures that required observations are obtained for geophysical stress levels up to and including extreme conditions. It is implicit in this parameter that the Horizontal Coverage includes all longitudes as permitted by the satellite orbit.
Objective	Global
Clarification	The global measurement of this EDR has limited operational utility beyond the extreme levels covered by the threshold requirement. Future DoD ionsopheric models may, however, be responsive to the extraordinary levels of geomagnetic stress included in this objective value. Global in this context refers to detecting the auroral boundary at all latitudes.

Note: Threshold value for *Horizontal Coverage* was previously defined in terms of an unspecified magnetic geometry. The current definition is now made in terms of a geographic reference. Previous objective level of *TBD* is now *Global* to fully cover the range of all possibilities.

EDR 40.8.1
Auroral Boundary

Paragraph No.	40.8.1-3
Parameter	c. Measurement Range
Threshold	> 30º latitude, N/S
Clarification	The measurement range in this context is the same as the Horizontal Coverage threshold parameter (40.8.1-1).
Objective	Global
Clarification	The measurement range in this context is the same as the Horizontal Coverage objective parameter (40.8.1-1).

EDR 40.8.1
Auroral Boundary

Paragraph No.	40.8.1-4
Parameter	d. Measurement Uncertainty

Threshold	50 km
Clarification	The threshold requirement for Measurement Uncertainity in locating the equatorial auroral boundary and the poleward boundary [*TBR*] is commensurate with 40.8.1-1. The threshold value for Measurement Uncertainty also satisfies DoD User needs for supporting radar operations. This threshold value corresponds to a latitudinal uncertainty of <1^{o} which, at present, is appropriate for specifying geophysical stress levels for the DOC.
Objective	10 km
Clarification	Provides a more accurate specification of details in the structure of the boundary that may be useful for future auroral ionospheric modeling efforts.

EDR 40.8.1
Auroral Boundary

Paragraph No.	40.8.1-5
Parameter	e. Reporting Frequency

Threshold	Twice per orbit
Clarification	The intent of this threshold parameter is a measurement of the equatorward boundary in each of the northern and southern auroral zones,; that is, one boundary measurement per hemisphere, per orbit. However, it is recognized that at times the NPOESS satellite may not intercept the auroral zone in one of the hemispheres. In this case, dual measurements of the equatorward boundary in one hemisphere would minimize the time delay between reports of successive crossings.
Objective	Four times per orbit
Clarification	Under fairly nominal conditions, the NPOESS orbit includes auroral crossings in both the north and the south. Under these conditions, it is preferred that the four low-latitude auroral boundary crossings be reported for each orbit. Knowledge of the high-latitude (poleward) auroral boundary is currently used in OpSEND for Surveillance radar support. However, the high-latitude boundary is more difficult to determine than the low-latitude boundary due to the more diffuse nature of the former. Therefore, determination of the poleward auroral boundary is an objective.

EDR 40.8.1
Auroral Boundary

Paragraph No.	40.8.1-6
Parameter	f . Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future *global* space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and *Dst* indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.2
Auroral Energy Deposition

Description: Auroral Energy Deposition refers to the energy flux into the ionosphere from precipitating auroral particles. These data are used to estimate the total auroral heat input into each hemisphere. The hemispheric power input can be determined from direct auroral particle measurements or auroral imagery. In-situ measurements of precipitating ion and electron fluxes may be combined with statistical models of auroral activity to provide an estimate of the hemispheric power input. The total heat input can also be derived from ultraviolet (UV) and/or X-ray auroral imagery. The threshold requirement for Auroral Energy Deposition is the set of measurements of the auroral heat flux along the satellite path in each hemisphere.

Usage: This EDR primarily supports DOC requirements for global situational awareness for increased levels of geophysical activity. The hemispheric power input is provided as a standard product via the NOAA/SEC web site @ http://www.sec.noaa.gov/today.html. DOD requirements are based on an anticipated need for monitoring the charged-particle energy input at auroral latitudes as an input for, as yet, undeveloped thermospheric specification models. These thermospheric specification models will be used to predict satellite drag parameters and as coupling inputs to future ionospheric specification and forecast models.

EDR 40.8.2
Auroral Energy Deposition

		Threshold	Objective
	a. Measurement Range		
40.8.2-1	1. Energy Flux	10^{-4} – 1 W/m^2	$5x10^{-5}$ – 1 W/m^2
40.8.2-7	2. Energy Range	100 eV to 20 keV	30 eV to 50 keV
40.8.2-2	b. Horizontal Cell Size	100 km	10 km
40.8.2-3	c. Horizontal Coverage	>30º Latitude, N/S	Global
40.8.2-4	d. Measurement Uncertainty	Greater of {10^{-4} W/m^2, 10%}	Greater of {$5x10^{-5}$ W/m^2, 5%}
40.8.2-5	e. Deleted		
40.8.2-6	f. Deleted		
40.8.2-8	g. Latency (Data Latency)	90 minutes	15 minutes
40.8.2-9	h. Horizontal Reporting Interval	100 km	10 km

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-1
Parameter	a.1. Measurement Range: Energy Flux
Threshold	10^{-4} - 1 W m^{-2}
Clarification	The lower value, 10^{-4} W m^{-2}, is the minimum energy flux that will produce a perceptible ionospheric and atmospheric response. The upper value, 1 W m^{-2}, is the maximum particle energy flux expected. The Measurement Range refers to the energy flux within the atmospheric loss cone as defined by charged particles having access to an altitude of 120 km.
Objective	5 x 10^{-5} - 1 W m^{-2}
Clarification	The objective will remove uncertainties during low levels of geophysical activity .

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-7
Parameter	a.2. Measurement Range: Energy Range

Threshold	100 eV to 20 keV
Clarification	Under nominal auroral activity conditions the bulk of the particle energy flow into the atmosphere is carried by particles within this energy range.
Objective	30 eV to 50 keV
Clarification	Under extreme auroral conditions significant energy into the atmosphere can be carried by particles up to 50 keV. During great geomagnetic storms large numbers of particles of energies as low as 30 eV enter the atmosphere at mid latitudes introducing significant changes in atmospheric densities at satellite altitudes.

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-2
Parameter	b. Horizontal Cell Size

Threshold	100 km
Clarification	The threshold Horizontal Cell Size satisfies current user needs. Present algorithms use the average energy flux within an approximate horizontal dimension of 100 km; that is, about 1° in latitude, to calculate the total hemispheric power input from auroral energetic particles. Data at this resolution is the minimum required to generate current User products.
Objective	10 km
Clarification	The increase in resolution for the objective will reduce uncertainties when the energy deposition is highly structured. These improved data can be used for future algorithm upgrades.

Note: The previous parameter designation for *Horizontal Spatial Resolution* is now defined in terms of *Horizontal Cell Size*.

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-3
Parameter	c. Horizontal Coverage

Threshold	> 30º latitude, N/S
Clarification	The threshold Horizontal Coverage ensures that required observations are obtained for geophysical stress levels up to and including extreme conditions. It is implicit in this parameter that the Horizontal Coverage includes all longitudes.
Objective	Global
Clarification	Current operational algorithms for total hemispheric power do not extend to latitudes below the threshold value. Therefore, the global measurement of this EDR has limited operational utility beyond the extreme levels covered by the threshold requirement. Future modeling efforts may, however, be responsive to the extraordinary levels of geomagnetic stress included in this objective value. The objective value also provides for consistency in coverage among several of the NPOESS space environmental EDR's; that is, Auroral Boundary (40.8.1) and Auroral Imagery (40.8.3).

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-4
Parameter	d. Measurement Uncertainty
Threshold	Greater of {10^{-4} W/m^2 or 10%}
Clarification	Current products use these measurements to determine auroral activity levels that differ by a factor of 1.58 in energy deposition from one level to the next. A 10% measurement uncertainty converts to an 80% certainty that the correct activity level is determined.
Objective	Greater of {5 x 10^{-5} W/m^2 or 5%}
Clarification	A reduction in measurement uncertainty to 5% converts to a 90% certainty that the correct activity level is determined.

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-9
Parameter	g. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future *global* space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and *Dst* indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.2
Auroral Energy Deposition

Paragraph No.	40.8.2-9
Parameter	h. Horizontal Reporting Interval
Threshold	100 km
Clarification	This is the same as the Horizontal Cell Size threshold and ensures a spatial continuity in measurements from one cell to the next.
Objective	10 km
Clarification	This is the same as the Horizontal Cell Size objective and ensures a spatial continuity in measurements from one cell to the next

EDR 40.8.3
Auroral Imagery

Description: Auroral Imagery refers to the two-dimensional (horizontal) imaging of the Earth's aurora. Imagery can be obtained at a variety of wavelengths, including the near infrared (IR), visible (VIS), ultraviolet (UV), and X-ray. Without specifying a hardware solution, it is not convenient to quantify the Measurement Range [40.8.3-4] for this EDR. Rather, this parameter is specified [*TBR*] in terms of the criteria used to rate auroral activity in DMSP images (Sheehan et al., *JGR, 87*, pp. 3581-3589, 1982; see also Table 12-2 in the Handbook of Geophysics and the Space Environment, 1985). The requirement is for images on both the day and night sides of the earth. The presence of scattered sunlight on the dayside effectively limits the choices to UV and X-ray sensors in the case that a single sensor is selected to satisfy this EDR.

Usage: This EDR supports DOD high-latitude radar systems by allowing identification of “hot spots” within the auroral zone that may be a source of clutter. However, the short-term dynamics of the aurora compared to the Local Average Revisit Time possible with the NPOESS constellation places certain limits the future operational utility of this EDR. On the other hand, future thermosphere and ionosphere specification models may require information on auroral structure that could be derived from this EDR. This EDR has application, also, as a possible technique for addressing several other EDR’s, notably, the Auroral Boundary (40.8.1), Auroral Energy Deposition (40.8.2), Electron Density Profile (40.8.5), and Neutral Density Profile (40.8.12).

EDR 40.8.3
Auroral Imagery

		Threshold	Objective
40.8.3-1	a. Horizontal Cell Size	25 km	10 km
40.8.3-2	b. Horizontal Reporting Interval	25 km	10 km
40.8.3-3	c. Horizontal Coverage	>30º Latitude, N/S	Global
40.8.3-4	d. Measurement Range	Mod. to very active aurora	Quiet to very active aurora
40.8.3-5	e. Measurement Uncertainty	10%	5%
40.8.3-6	f. Mapping Uncertainty	10 km	1 km
40.8.3-7	g. Max Local Ave Revisit Time	4 hours	15 minutes
40.8.3-8	h. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.3
Auroral Imagery

Paragraph No.		40.8.3-1
Parameter		a. Horizontal Cell Size
Threshold	25 km	
Clarification	A 25-km cell size is commensurate with identifying a boundary accurate to 50 km, as required by EDR 40.8.1-1.	
Objective	10 km	
Clarification	Provides a finer specification of details of auroral structure that may be useful for future modeling efforts.	

Note: The previous value for the Horizontal Cell Size threshold was deemed to be inadequate to address the Measurement Uncertainty for the Auroral Boundary EDR (40.8.1)

EDR 40.8.3
Auroral Imagery

Paragraph No.	40.8.3-2
Parameter	b. Horizontal Reporting Interval

Threshold	25 km
Clarification	This is the same as the Horizontal Cell Size threshold and ensures a spatial continuity in measurements from one cell to the next.
Objective	10 km
Clarification	This is the same as the Horizontal Cell Size objective and ensures a spatial continuity in measurements from one cell to the next.

Note: See 40.8.3-2 for the justification in the change for Horizontal Cell Size. The objective value for Horizontal Reporting Interval (40.8.3-3) was changed from "Horizontal Cell Size" to 10 km to avoid confusion in the distinct definitions for these two parameters (see the NPOESS Requirements Documents, Appendix A – Definition /Glossary of Terms).

EDR 40.8.3
Auroral Imagery

Paragraph No.	40.8.2-3
Parameter	c. Horizontal Coverage

Threshold	>30º latitude, N/S
Clarification	The intent of the threshold is to monitor the auroral zone under all but the most extreme levels of geophysical activity. The threshold Horizontal Ceverage ensures that required observations are obtained for geophysical stress levels up to and including extreme conditions. The specific threshold value is driven by the associated needs of the Auroral Boundary [40.8.1] and Auroral Energy Deposition [40.8.2] EDRs.
Objective	Global
Clarification	The objective value provides for consistency in coverage among several of the NPOESS space environmental EDR's; that is, Auroral Boundary (40.8.1) and Auroral Imagery (40.8.3).

EDR 40.8.3
Auroral Imagery

Paragraph No.		40.8.3-4
Parameter		d. Measurement Range
Threshold	Moderate to very active aurora	
Clarification	The qualitative nature on this parameter is based on the categorizations per the references provided in the general introduction to this EDR. The requirement was purposely left qualitative because specification of wavelength ranges and/or brightness levels would effectively specify a particular sensor solution. The selected sensor must be capable of measuring auroral characteristics; for example, arcs, boundaries, active auroral regions, under moderate to active conditions (K_p >1+). This can be done through the use of models of auroral activity and associated particle emissions. A threshold for identifying bright features could be tied to an incident energy flux (perhaps 0.1-to-0.5 ergs [*TBD*]). Moderate or better activity levels are specified as a threshold because these are the conditions that have the most significant impact on operational systems.	
Objective	Quiet to very active aurora	
Clarification	The extended coverage for the objective measurement range may be useful in future, that is, more sensitive, applications of radar operations. The utility if this extended range has not, however, been adequately demonstrated.	

EDR 40.8.3
Auroral Imagery

Paragraph No.	40.8.3-5
Parameter	e. Measurement Uncertainty

Threshold	10%
Clarification	The threshold requirement specifies that discrete auroral features having dimension of order 25 km (see Horizontal Cell Size, 40.8.3-1) or greater should be clearly identifiable in the imagery. The appropriate Measurement Uncertainty should be based on an analysis using the proposed sensor solution.
Objective	5%
Clarification	The objective requirement provides for some improved definition of weak auroral features such as quiet-time auroral arcs or diffuse auroral emissions.

EDR 40.8.3
Auroral Imagery

Paragraph No.	40.8.3-6
Parameter	f. Mapping Uncertainty

Threshold	10 km
Clarification	The threshold Mapping Uncertainty was specified to ensure that all systematic and random errors affecting the geolocation of large-scale auroral features ; i.e., the Auroral Boundary (40.8.1), are adequately specified by the Horizontal Cell Size (40.8.3-1). The Mapping Uncertainty is specified at nadir whereas the Edge of Scan (EOS) errors are [*TBD*] in accordance with the adopted solution.
Objective	1 km
Clarification	The objective-level Mapping Uncertainty Is useful for geolocating fine-scale auroral features associated with the objective Horizontal Cell Size; that is, 10 km.

EDR 40.8.3
Auroral Imagery

Paragraph No.	40.8.3-7
Parameter	g. Maximum Local Average Revisit Time
Threshold	4 hours
Clarification	The threshold value for Maximum Local Average Revisit Time provides a characterization of changes in auroral activity over relatively large time scales associated with providing “situational awareness” of the space environment. The basis of this parameter is a consideration of the average time between successive overflights of a mid-latitude station, say 30^{o} geographic, by a remote-sensing satellite system having overlapping fields of view from one orbit to the next.
Objective	15 minutes
Clarification	An objective level of 15 minutes for the Maximum Local Average Revisit Time would satisfy the needs of current radar operators for timely updates in the local auroral morphology. It is understood, however, that this objective exceeds any reasonable expectations for a NPOESS-type solution and is not in any current CONOPS for supporting radar users. The contractor should perform reasonable trades between the threshold value of this parameter and the perceived needs of the radar community. Local Average Revisit Times of less than 1-hour are possible above 60^{o} with a 3-ball NPOESS constellation.

EDR 40.8.3
Auroral Imagery

Paragraph No.	40.8.3-8
Parameter	h. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.4
Electric Field

Description: This EDR is the in-situ measurement of local, quasi-DC electric fields. Electric fields can be measured directly or inferred from associated measurements of convection. Electric fields in the ionosphere drive the transport of plasma (convection) and, at high latitudes, provide a "footprint" of magnetospheric convection. The polar-cap potential, calculated as the integral of the electric fields within the polar cap, nominally dawn to dusk, is an indicator of geophysical activity. Electric fields are also to be used to estimate the Joule heat input in the auroral zones. At low latitudes the electric field can be used to forecast the onset of ionospheric scintillation. The requirement for this EDR is the set of measurements of the electric field along the satellite path. While it is recognized that convection provides the components of the electric field perpendicular to the local magnetic field, a determination of the plasma flow along the magnetic field line is also required.

Usage: The electric field is used in a variety of current and future User Products. Present applications use the derived polar-cap potential as both an input to the Magnetospheric Specification Model (DOD) and as an indication of geophysical activity levels (DOC). In the near-term electric field will also be used in the OpSEND radar clutter product. The electric field can also be used monitor the motion of high-latitude plasma patches and blobs that affect Communications and Surveillance radars. At low latitudes, the electric field can be combined with the drift along B to derive the electron density profile and plasma instability growth rates. This data complements the C/NOFs mission.

EDR 40.8.4
Electric Field

		Threshold	Objective
40.8.4-1	a. Measurement Range	0 to ± 150 mV m^{-1}	0 to ± 250 mV m^{-1}
40.8.4-2	b. Horizontal Cell Size	10 km [TBR]	1 km [TBR]
40.8.4-3	c. Horizontal Reporting Interval	10 km [TBR]	1 km [TBR]
40.8.4-4	d. Horizontal Coverage	Global	Global
40.8.4-5	e. Measurement Uncertainty	3 mV m^{-1}	0.1 mV m^{-1}
40.8.4-6	f. Measurement Precision	2 mV m^{-1}	0.1 mV m^{-1}
40.8.4-7	g. Deleted		
40.8.4-8	h. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.4
Electric Field

Paragraph No.	40.8.4-1
Parameter	a. Measurement Range

Threshold	0 to ±150 mV m-1
Clarification	The threshold includes the expected range for the average convective electric field during periods of quiet to extreme geophysical activity. The intent of this vector measurement at the threshold is not to measure the maximum amplitude of any rapidly fluctuating electric fields but, rather, the average convective field at the scale-size defined by the threshold Horizontal Cell Size (40.8.4-2).
Objective	0 to ±250 mV m-1
Clarification	This objective-level parameter extends the range of the electric field measurement in order to be responsive to periods of extraordinary geophysical activity. This parameter level also provides for improved measurements of large-amplitude, rapidly-varying fields when coupled to the objective Horizontal Cell Size.

EDR 40.8.4
Electric Field

Paragraph No.	40.8.4-2
Parameter	b. Horizontal Cell Size

Threshold	10 km [TBR]
Clarification	Current user products require as input the large-scale E-field; that is, the quasi-DC convective electric field. The threshold Horizontal Cell Size provides for a reasonable extrapolation of capability over current operational sensors that use a combined driftmeter and retarding potential analyzer approach.
Objective	1 km [TBR]
Clarification	The objective level may have application in providing improved estimates of Joule heating at auroral latitudes and for improving scintillation prediction techniques at both low and high latitudes.

EDR 40.8.4
Electric Field

Paragraph No.	40.8.4-3
Parameter	c. Horizontal Reporting Interval
Threshold	10 km [TBR]
Clarification	This is the same as the Horizontal Cell Size threshold and ensures a spatial continuity in measurements from one cell to the next.
Objective	1 km [TBR]
Clarification	This is the same as the Horizontal Cell Size objective and ensures a spatial continuity in measurements from one cell to the next.

EDR 40.8.4
Electric Field

Paragraph No.		40.8.4-4
Parameter		d. Horizontal Coverage
Threshold	Global	
Clarification	Current User products are geared towards mid- to high-latitude measurements of the convective electric field. However there is a strong interest in using these data for high- and low-latitude scintillation prediction. Depending upon the level of geophysical activity the classification of high, middle, and low latitudes will overlap. Setting the threshold for a global measurement avoids any misclassification and potentially lost data.	
Objective	Global	
Clarification	Objective is the same at threshold.	

EDR 40.8.4
Electric Field

Paragraph No.	40.8.4-5
Parameter	e. Measurement Uncertainty

Threshold	3.0 mV m^{-1}
Clarification	The threshold level for Measurement Uncertainty is adequate to support the generation of high-latitude user products; that is, the polar-cap potential and the degree of geophysical activity. To some degree, this threshold is driven by the needs to detect and predict equatorial irregularities that are responsible for scintillation.
Objective	0.1 mV m^{-1}
Clarification	The objective level may be needed to support future low-latitude predictive model of scintillation.

EDR 40.8.4
Electric Field

Paragraph No.	40.8.4-6
Parameter	f. Measurement Precision

Threshold	2 mV m^{-1}
Clarification	For the most part, the GAT felt that the parameter for Measurement Uncertainty (40.8.4-5) is sufficient to support current User Products. It is noted, however, that this threshold requirement for Measurement Precision allocates most of the Measurement Uncertainty in 40.8.4-5 to statistical errors. This EDR will be used in CONOPS that integrate the derived electric field across the polar cap. The resulting polar-cap potential is critically dependent on the accuracy of the EDR – a small offset in the EDR will amount to a large error in the polar-cap potential. Allocating most of the Measurement Uncertainty to Measurement Precision will help minimize the Measurement Accuracy in the EDR.
Objective	0.1 mV m^{-1}
Clarification	The objective parameter will be used in future user products in scintillation prediction in support of Satellite Communications (SATCOM) and HF Comm.

EDR 40.8.4
Electric Field

Paragraph No.	40.8.4-8
Parameter	h. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage “store and dump” communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.5
Electron Density Profile

Description: This EDR is a measure of the electron density profile (EDP) and the total electron content (TEC) of the ionosphere. The nominal ionosphere extends from the lower D at 60 km, up through the E and F_2-regions that peak around 100 km and 250 km, respectively. The ionosphere also stretches into the topside ionosphere up to about 1600 km and to the inner edge of the plasmasphere near 3000 km. The maximum density typically occurs at the F_2 peak. The ionosphere is often expressed in terms of characteristic features; that is, Chapman layers. The EDR requirement is for a determination of the local EDP within the primary range of interest; that is, between 90 and 800 km. The characteristic features that are used to describe the EDP are also included in this EDR.

Usage: User needs fall into three broad categories; 1) a DOC requirement for data leading to situational awareness, 2) requirements to correct for changes in electromagnetic wave propagation induced by the ionosphere, and 3) requirements to calculate and forecast ionospheric disturbances that impact DOD and civilian systems. The AF, Navy and Army have stringent requirements for specification and forecast of the EDP and TEC. These parameters are needed either for global models or specific theater-level models. Estimates of the EDP and the TEC – either locally or globally — are optimized by assimilating data from multiple sources, applying physics-based algorithms, and using empirical models for some of the parameters that have an effect on the EDP. Furthermore the operational need is for nowcast as well as forecast of the EDP and TEC.

EDR 40.8.5
Electron Density Profile

Other Comments:

Recent factors that were not present in September 1998 when the SESG report was issued are responsible for some of the suggested changes in this EDR. For example, the DOD now uses four operational Space Weather products that are based on this EDR. These are part of the OpSEND products, and include: the HF Illumination Map, the GPS Error Map, the Scintillation Decision Aid, and the Radar Auroral Clutter Map.

Although the use of Automated Link Establishment (ALE) technology for HF communications will facilitate civilian HF communications, ALE is not an acceptable solution under all circumstances. In particular, it is not practical to use ALE during covert operations. AF Special Operations Command (AFSOC) has stringent requirements in terms of end-to-end reliable secure connectivity that need to be tackled by EDP measurements. Recent work during the Foal Eagle exercises in South Korea has dramatically illustrated the need for reliable HF ionospheric products such as the HF Illumination Maps that are part of the OpSEND system.

Additionally, the Intelligence, Surveillance, Reconnaissance (ISR) community has identified deficiencies that can only be addressed by measuring the Electron Density Profile (EDP).

An outcome of the planned modifications in the National Missile Defense (NMD) system is an increase in requirements for EDP measurements at high latitudes. These requirements can be met, in part or in full, by this EDR.

EDR 40.8.5
Electron Density Profile

		Threshold	Objective
	a. Measurement Range		
40.8.5-1	1. Density, n_e	$2.5 \times 10^4 - 10^7$ cm^{-3}	$10^4 - 10^7$ cm^{-3}
40.8.5-2	2. TEC (vertical)	3 – 200 TECU	1 – 200 TECU
	3. Feature		
40.5.5-3	n_mF_2	$10^5 - 10^7$ cm^{-3}	$10^4 - 10^7$ cm^{-3}
40.8.5-4	h_mF_2	150 – 700 km	150 – 800 km
40.8.5-5	n_mE	$10^5 - 10^7$ cm^{-3}	$10^4 - 10^7$ cm^{-3}
40.8.5-6	h_mE	90 – 150 km	90 – 150 km
40.8.5-7	λ_{height}	N/A	[TBD]
40.8.5-8	h_{trans}	N/A	[TBD]
40.8.5-9	$n_{in\text{-}situ}$	$5 \times 10^3 - 5 \times 10^6$ cm^{-3}	$10^2 - 10^7$ cm^{-3}
40.8.5-10	$TEC_{overhead}$	N/A	[TBD]
40.8.5-11	Ion composition	N/A	O_2^+, NO^+, O^+, H^+, He^+
40.8.5-12	b. Horizontal Coverage	Global	Global
40.8.5-13	c. Vertical Coverage	90 km – satellite altitude	60 – 3000 km

Continued on next slide

Reference: 1 TECU = 10^{12} cm^{-2}

EDR 40.8.5
Electron Density Profile

continued

		Threshold	Objective
	d. Horizontal Cell Size		
40.8.5-14	1. Latitudes: 0 - 30º, ***N/S***	100 km	10 km
40.8.5-15	2. Latitudes: 30 - 90º, ***N/S***	50 km	10 km
40.8.5-16	3. Deleted		
	e Vertical Cell Size (EDP)		
40.8.5-17	1. 90 – 500 km	10 km	3 km
40.8.5-18	2. above 500 km	20 km	5 km
40.8.5-19	f. Horizontal Reporting Interval	Horizontal Cell Size	Horizontal Cell Size
40.8.5-20	g. Vertical Reporting Interval (EDP)	Vertical Cell Size	Vertical Cell Size
	h. Measurement Uncertainty		
40.8.5-21	1. Density, n_e	Greater of {10^5 cm^{-3}, 30%}	Greater of (10^4 cm^{-3}, 5%}
40.8.5-22	2. TEC (vertical)	Greater of {3 TECU, 30%}	Greater of {1 TECU, 30%}
	3. Feature		
40.5.5-23	n_mF_2	20%	10%
40.8.5-24	h_mF_2	20 km	5 km

Continued on next slide

EDR 40.8.5
Electron Density Profile

continued

		Threshold	Objective
40.8.5-25	n_mE	20%	5%
40.8.5-26	h_mE	10 km	3 km
40.8.5-27	λ_{height}	N/A	[TBD]
40.8.5-28	h_{trans}	N/A	[TBD]
40.8.5-29	$n_{in\text{-}situ}$	Greater of {10^4 cm^{-3}, 20%}	Greater of {$2x10^2$ cm^{-3},5%}
40.8.5-30	$TEC_{overhead}$	N/A	[TBD]
40.8.5-31	Ion composition	N/A	5% of the local density, n_e
40.8.5-32	i. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-1
Parameter	a.1. Measurement Range – Density, n_e

Threshold	2.5×10^4 - 10^7 /cm^{-3}
Clarification	The threshold requirement covers the full range of expected electron densities within the threshold range of vertical coverage. Current CONOPS supporting HF Comm require identification of key ionospheric features; for example, N_mF_2, h_mF_2, and n_mE. The threshold upper value is required to adequately discern and measure these features. National Programs require the specification of the TEC along arbitrary slant-angle paths through the ionosphere. This arbitrary slant path requirement implies the need for a profile specification. The lower value is prescribed from a need to have the vertical TEC known within 3 TECU (see 40.8.5-2).
Objective	10^4 - 10^7 /cm^{-3}
Clarification	The objective range extends the lower value to10^4 cm^{-3}. This value directly supports National Program that drive vertical TEC to within 1 TECU.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-2
Parameter	a.2. Measurement Range - TEC (vertical)

Threshold	3 – 200 TECU
Clarification	CONOPS supporting National Programs require a near real-time specification of the ionospheric TEC along an arbitrary slant path from ground to an arbitrary altitude. The upper value for threshold TEC (vertical) is consistent with the integrated electron content through the ionosphere over the full range of geophysical conditions. The lower value is driven by the sensitivity requirements to satisfy National Program threshold needs.
Objective	1 – 200 TECU
Clarification	The objective range extends the lower value for TEC (vertical) to 1 TECU. The lower value satisfies National Program objective requirements.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-3
Parameter	a.3. Measurement Range – Feature - n_mF_2

Threshold	10^5 - 10^7 cm^{-3}
Clarification	This parameter supports a variety of user needs for HF Comm and geolocation. The threshold range can provide military users of HF Comm a specification of the Maximum Unsable Frequency (MUF) for transmission. Presently, DMSP data are used as input to the Parameterized Real-time Ionospheric Specification Model (PRISM) and incorporated into the existing CONOPS for improved products. The peak value for this parameter has the most critical affect on geolocation and HF Comm when the F_2 densities are high. The lower value is derived from a consideration that scintillation effects are unimportant when the density is low.
Objective	10^4 - 10^7 cm^{-3}
Clarification	The extension of this parameter range to a lower value considers the needs for HF comm Users; specifically, when $N_mF_2 < 10^4$ cm^{-3} then HF communication is not practical.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-4
Parameter	a.3. Measurement Range – Feature - h_mF_2

Threshold	150 – 700 km
Clarification	The height of the F_2 peak is a critical element in assuring the connectivity for surface-to-surface HF Comm users. While the location of the F_2 peak is normally between 200 and 350 km, this location can reach, at times, the upper value in the Measurement Range. As in the case of the previous parameter, DMSP data is presently used as input to PRISM and incorporated into CONOPS supporting HF Comm. The height of the F_2 peak within the threshold range can also support future CONOPS for scintillation prediction at low latitudes.
Objective	150 – 800 km
Clarification	Under conditions of extreme geophysical stress, the h_mF_2 upper value can reach and possibly exceed the objective level of 800 km.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-5	
Parameter	a.3. Measurement Range – Feature - n_mE	
Threshold	$10^5 – 10^7\ cm^{-3}$	
Clarification	In addition to the F-region features previously discussed, knowledge of the density (and height) of the E-region peak is an implicit parameter used in the generation of HF Comm products. The current CONOPS do not support the direct measurement of the n_mE but, rather, use an empirical determination of this parameter driven by the $F_{10.7}$ flux and K_p. Currently, the DMSP is assessing the capability and validity of measuring the N_mE from space using the new SSUSI sensor (auroral). If effective, it is likely that these data will be used in the PRISM model to generate user support products for HF Comm and auroral clutter. The threshold range for N_mE is the anticipated range for this parameter including the effects of sporatic-E under quiet to active periods. Present CONOPS for radar clutter assessments are based on E-region information.	
Objective	$10^4 – 10^7\ cm^{-3}$	
Clarification	The objective range for this parameter includes an extension of the threshold to lower densities for quiet geophysical conditions.	

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-6
Parameter	a.3. Measurement Range – Feature - h_mE

Threshold	90 – 150 km
Clarification	The requirements for h_mE are driven by a need to specify the presence of auroral clutter for radar operations and to support the need of HF Comm when a distinct E-region peak is present. The Measurement Range specified above is considered to be the full range of h_mE anticipated under virtually all geophysical conditions.
Objective	90 – 150 km
Clarification	Objective is the same as threshold.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-7	
Parameter	a.3. Measurement Range – Feature - λ_{height}	
Threshold	N/A	
Clarification	This is an objective parameter.	
Objective	[*TBD*]	
Clarification	The scale height, $\lambda_{height,}$ refers to the e-folding decrease of n_e with altitude. There are no current CONOPS which require this parameter. However, these data may be useful in future CONOPS using PRISM or some other ionospheric specification and / or prediction model in support of SatCom, Navigation, National Program, and DOC needs. Typical values for the scale height range from about 106 km (for T_i=1000 ^oC, O^+) just above the F_2 peak to perhaps several times that value near NPOESS altitudes.	

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-8
Parameter	a.3. Measurement Range – Feature - h_{trans}

Threshold	N/A
Clarification	This is an objective parameter.
Objective	[*TBD*]
Clarification	The transition height, h_{trans}, is the altitude from the dominance from heavy ions to light ions. Typically, this parameter ranges between 600 km and 1000 km under most geophysical conditions. This parameter may be needed implicitly to calculate the n_e over the full Vertical Coverage (40.8.5-13) for the EDP. By itself, parameter is not needed in any current CONOPS. However, this parameter may be useful to constrain PRISM in some future upgrades to this model or in some other first-principles ionospheric model.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-9
Parameter	a.3. Measurement Range – Feature - $n_{in\text{-}situ}$
Threshold	5×10^{3}- 5×10^{6} cm^{-3}
Clarification	This revised parameter establishes a requirement for an in-situ measurement of the local plasma density, $n_{In\text{-}situ}$. It was felt by the GAT that any reasonable approach to measuring the EDP over the Vertical Coverage range (40.8.5-13) must be constrained by a local measurement of $n_{In\text{-}situ}$. This parameter is also included in the In-situ Plasma Fluctuations EDR as a requirement for mean plasma density (40.8.9-3). The threshold Measurement Range includes the expected variation of this parameter at 800 km altitude for most geophysical conditions.
Objective	10^{2} - 10^{7} /cm^{-3}
Clarification	The extended range for the objective includes detection of equatorial depletion zones (lower value) and periods of extreme geophysical activity (upper value).

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-10
Parameter	a.3. Measurement Range – Feature - $TEC_{overhead}$

Threshold	N/A
Clarification	This is an objective parameter.
Objective	[*TBD*]
Clarification	The overhead Total Electron Content, $TEC_{overhead}$, is that component of the vertical TEC above the NPOESS satellite. During normal geophysical conditions the overhead TEC, or plasmaspheric component, is expected to contribute up to several TECU to the overall vertical TEC. Current CONOPS for ground-measured TEC supporting National Programs require TEC (arbitrary slant path) uncertainties of 2 or 3 TECU. Thus the overhead component of TEC should be a consideration for future CONOPS using NPOESS TEC. Note that this parameter is not constrained by the Vertical Coverage parameter in 40.8.5-13. For practical reasons, however, the overhead contribution to TEC is limited to altitudes within about 20,200 km (GPS orbit) or 35,000 km (GEO) depending upon the implementation – the difference between GPS and GEO should be insignificant.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-11
Parameter	a.3. Measurement Range - Feature - Ion Composition

Threshold	N/A
Clarification	This is an objective parameter.
Objective	O_2+, NO+, O+, H+, He+
Clarification	Need to update - Currently, there are no specific CONOPS that require Ion Composition data. However, the SSIES sensor on DMSP does provide limited information regarding the in-situ ion composition at DMSP altitudes and this knowledge can be used in PRISM to better specify the topside ionosphere in near-term CONOPS supporting the SatCom and Navigation mission areas and National Programs.

EDR 40.8.5
Electron Density Profile

Paragraph No.		40.8.5-12
Parameter		b. Horizontal Coverage
Threshold	Global	
Clarification	Current DOD/DOC requirements for the EDP specification are for all locations, at all times, and under all geophysical conditions. The threshold requirement for this parameter must consider these general needs.	
Objective	Global	
Clarification	Objective is the same as threshld.	

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-13
Parameter	c. Vertical Coverage

Threshold	90 km to satellite altitude
Clarification	The primary range of interest that affect current CONOPS for HF Comm and the civilian sector are the E- and F-regions. The threshold values for Vertical Coverage bounds this range of primary interest for most geophysical conditions. Future CONOPS supporting Navigation, SatCom and National Programs through application of an assimilative or driven first-principles ionsopheric model will require contiguous data throughout this Vertical Coverage range.
Objective	60 to 3000 km
Clarification	The objective vertical range of coverage is extended both below and above the values bounding the threshold range. The lower altitude objective is to provide a means to measure the ionospheric D-region, down to 60 km. Under certain conditions, penetrating solar protons can ionize the background thermosphere at D-region altitudes causing a Polar Cap Absorption (PCA) event which can affect HF Comm. Upper value provides for an improved ionospheric specification beyond that provided by the $TEC_{Overhead}$ (40.8.5-10) in order to support future National Program needs.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-14
Parameter	d.1. Horizontal Cell Size – Latitudes: 0-30^0, N/S
Threshold	100 km
Clarification	The equatorial ionosphere is a region of small-to-moderate spatial variation. The threshold value for the Horizontal Cell Size (HCS) provides for a resolution of about 1^o allowing for the clear identification of macroscopic features such the Appleton Anomalies and eveningside, large-scale scintillation structures. Emerging CONOPS for low-latitude scintillation specification and prediction as part of the Communication/Navigation Outage Forecast System (C/NOFS) will provide User products having a resolution at the threshold HCS. This resolution may also prove useful in identifying source regions for Equatorial Spread-F (ESF) from gravity wave seeding and motional shear effects.
Objective	10 km
Clarification	The improved spatial resolution for the objective may have application for future CONOPS in predicting equatorial F-region scintillation by detecting localized density structures sensitive to the Rayleigh-Taylor instability. In general, the higher resolution measurements will lead to better EDP characterizations and more accurate scintillation strength estimates.

Note: The Horizontal Cell Size (HCS) for the EDP has been divided into two distinct regions, an equatorial-to-mid latitudinal range and a mid-to-high latitudinal range. Previously, the HCS for EDP was divided into three zones for equatorial, middle, and high latitudes. This change is consistent with the previously stated objective of removing references to a geomagnetic reference.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-15
Parameter	d.2. Horizontal Cell Size, Latitudes: 30-90^{o}, N/S
Threshold	50 km
Clarification	The threshold Horizontal Cell Size (HCS) is near the minimum size for typical large-scale plasma structures in the high-latitude F-region. At present, there are two CONOPS that use global EDPs to support user needs. In future CONOPS the EDP may be required to validate range-correction models and to provide high-latitude scintillation / clutter support. High-latitude EDPs may also be needed for improved geolocation corrections for single-frequency GPS users. It should be noted that this parameter refers to the auroral and high-latitude ionosphere – within the mid-latitude ionosphere the HCS can be relaxed considerably.
Objective	10 km
Clarification	The objective HCS is less than the typical scale size for large-scale plasma structures in the high-latitude F-region. A more precise measurement of plasma density gradients will lead to improved operational support to Navigation, HF-Comm, and other applications.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-17
Parameter	e.1. Vertical Cell Size - 90 to 500 km
Threshold	10 km
Clarification	At lower altitudes the threshold requirement for Vertical Cell Size (VCS) is compliant with the current operational requirement for h_mE to be known to within 10 km (40.8.5-26) in support of HF Comm. At higher altitudes the requirement is for scintillation prediction in emerging CONOPS supporting HF Comm where the bottom-side density gradient needs to be known with sufficient accuracy to calculate the irregularity growth-rates, particularly near the equator.
Objective	3 km
Clarification	The objective level for Vertical Cell Size provides a more accurate measure of plasma density gradients that will lead to a more accurate scintillation prediction in future CONOPS.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-18
Parameter	e.2. Vertical Cell Size - above 500 km

Threshold	20 km
Clarification	The threshold requirement is impacted by current CONOPs supporting HF Comm in specifying the h_mF_2 with threshold Measurement Uncertainty of 20 km (40.8.5-24). It is also recognized that the resolution for measuring the plasma density gradient within the topside ionosphere can be, in general, relaxed from that specified at lower altitudes with minor impacts on emerging and future ionospheric models that are used in CONOPS supporting HF Comm, Navigation, and National Programs.
Objective	5 km
Clarification	This obective-level requirement in guided by the objective needs for specifying the h_mF_2 to within 5 km (40.8.5-24). In general, the smaller cell size will lead to improved data inputs for future models and improved user products.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-19
Parameter	f. Horizontal Reporting Interval

Threshold	Horizontal Cell Size
Clarification	The threshold requirement for Horizontal Reporting Interval is set to the same resolution as the Horizontal Cell Size to ensure contiguous reports of this EDR within successive cells.
Objective	Horizontal Cell Size
Clarification	The objective parameter for Horizontal Reporting Interval is set to the same resolution as the Horizontal Cell Size to ensure contiguous reports of this EDR within successive cells.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-20
Parameter	g. Vertical Reporting Interval (EDP)
Threshold	Vertical Cell Size
Clarification	The threshold requirement for Vertical Reporting Interval is set to the same resolution as the Vertical Cell Size to ensure contiguous reports of this EDR within successive cells.
Objective	Vertical Cell Size
Clarification	The objective parameter for Vertical Reporting Interval is set to the same resolution as the Vertical Cell Size to ensure contiguous reports of this EDR within successive cells.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-21
Parameter	h.1. Measurement Uncertainty: Density, n_e
Threshold	Greater of {10^5 cm^{-3}, 30%}
Clarification	The threshold Measurement Uncertainty for density was based on the lower vaues for the Measurement Range in density (40.8.5-1). The rationale for the hybrid nature of the uncertainty requirement was to provide a reasonable transition from an uncertainty that may be dictated by bit quantization or insufficient resolution at the lowest measured densities to a percentage uncertainty at the higher densities. There was a concern that casting this requirement in terms of a percentage only might drive sensor complexity without sufficient CONOPS to justify the costs. The percentage requirement, applicable to the higher densities, is based on a reasonable assumption regarding CONOPS supporting the needs of HF Comm and National Program users for atmospheric characterization in terms of fundamental ionospheric features; that is, N_mF_2, h_mF_2, N_mE, and TEC.
Objective	Greater of {10^4 cm^{-3}, 5%}
Clarification	The objective level for Measurement Uncertainty is based on similar arguments to that of the above with a perceived need for improved density resolution to support possible future CONOPS in HF Comm.

Note: There is a disconnect between the lower density range requirement; that is 3×10^4 cm^{-3}, and the uncertainty of 10^5 cm^{-3} which was driven by concerns regarding sensor complexities and lack of a supporting CONOPS at the lowest densities.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-22
Parameter	h.2. Measurement Uncertainty: TEC (vertical)
Threshold	Greater of {3 TECU, 30%}
Clarification	This threshold requirement is commensurate with the Measurement Range specification in 40.8.5-2. These requirements are based on existing CONOPS supporting the needs of National Programs and Space Surveillance radar systems, both of which are described in terms of arbitrary slant-angle TEC. The rationale for the hybrid nature of the uncertainty requirement was to provide a reasonable transition from an uncertainty that may be dictated by bit quantization or insufficient resolution at the lowest measured values of TEC to a percentage uncertainty at the higher values.
Objective	Greater of {1 TECU, 30%}
Clarification	The objectives for this parameter are commensurate with the Measurement Range specification in 40.8.5-2.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-23
Parameter	h.3. Measurement Uncertainty – Feature - n_mF_2

Threshold	20%
Clarification	This threshold requirement is traceable to existing CONOPS supporting the threshold needs of HF Comm users. This uncertainty also supports current derived requirements for Navigation, National Programs and Radars dictated by TEC uncertainties. In future CONOPS this uncertainty will help constrain emerging assimilative ionospheric models and future ionospheric specification and forecast models.
Objective	10%
Clarification	This objective is traceable to current user objective needs and future needs supporting ionospheric modeling in User CONOPS.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-24
Parameter	h.3. Measurement Uncertainty – Feature - h_mF_2

Threshold	20 km
Clarification	The threshold requirement for Measurement Uncertainty, h_mF_2, is traceable to existing CONOPS supporting the threshold needs of HF Comm users. This uncertainty also supports current derived requirements for Navigation, National Programs and Space Surveillance Radars dictated by TEC uncertainties. In future CONOPS this uncertainty will help constrain emerging assimilative ionospheric models and future ionospheric specification and forecast models.
Objective	5 km
Clarification	This objective is traceable to current user objective needs and future needs supporting ionospheric modeling in user CONOPS.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-25	
Parameter	h.3. Measurement Uncertainty- Feature - n_mE	
Threshold	20%	
Clarification	This threshold requirement is traceable to existing CONOPS supporting the threshold needs of HF Comm users. This uncertainty also supports current derived requirements for Navigation, National Programs and Space Surveillance Radars dictated by TEC uncertainties. In future CONOPS this uncertainty will help constrain emerging assimilative ionospheric models and future ionospheric specification and forecast models. At high latitudes this measurement uncertainty will facilitate Joule heating calculations using in ionospheric models.	
Objective	5%	
Clarification	This objective is traceable to current user objective needs and future needs supporting ionospheric modeling in user CONOPS.	

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-26
Parameter	h.3. Measurement Uncertainty – Feature - h_mE

Threshold	10 km
Clarification	This threshold requirement is traceable to existing CONOPS supporting the threshold needs of HF Comm users. This uncertainty also supports current derived requirements for Navigation, National Programs and Space Surveillance Radars dictated by TEC uncertainties. In future CONOPS this uncertainty will help constrain emerging assimilative ionospheric models and future ionospheric specification and forecast models. At high latitudes this measurement uncertainty will facilitate Joule heating calculations using in ionospheric modeling. This threshold requirement is also commensurate with requirements related to Medium Energy Charged Particles EDR (40.8.13).
Objective	3 km
Clarification	This objective is traceable to current user objective needs and future needs supporting ionospheric modeling in User CONOPS. In general, this objective will lead to more accurate HF Comm products and Joule heating calculations.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-27	
Parameter	h.3. Measurement Uncertainty – Feature - λ_{height}	
Threshold	N/A	
Clarification	This is an objective parameter.	
Objective	[*TBD*]	
Clarification	This parameter is not directly used in any existing CONOPS. This objective parameter is desired to facilitate the calculation of the EDP in ionospheric modeling used in future CONOPS supporting HF Comm, Navigation, Space Surveillance Radar, and National Program needs.	

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-28
Parameter	h.3. Measurement Uncertainty - Feature - h_{trans}
Threshold	N/A
Clarification	This is an objective parameter.
Objective	[*TBD*]
Clarification	This parameter is not directly used in any existing CONOPS. This objective parameter is desired to facilitate the calculation of the EDP in ionospheric modeling in future CONOPS supporting HF Comm, Navigation, Space Surveillance Radar, and National Program needs.

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-29
Parameter	h.3. Measurement Uncertainty – Feature – $n_{in\text{-}situ}$
Threshold	Greater of {10^4 cm^{-3}, 20%}
Clarification	This threshold parameter has been revised for consistency with the threshold requirement for Measurement Uncertainty, Mean Plasma Density in the EDR for In-situ Plasma Fluctuations (40.8.9-7).
Objective	Greater of {$2x10^2$ cm^{-3}, 5%}
Clarification	This threshold parameter has been revised for consistency to the objective parameter for Measurement Uncertainty, Mean Plasma Density in the EDR for In-situ Plasma Fluctuations (40.8.9-7).

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-30
Parameter	h.3. Measurement Uncertainty – Feature - $TEC_{overhead}$
Threshold	N/A
Clarification	This is an objective parameter.
Objective	[*TBD*]
Clarification	This parameter has application in future CONOPS supporting National Program and Space Surveillance System needs for space-based measurements of arbitrary slant-angle TEC (ground-to-space TEC assumed). National Programs require TEC uncertainties of order, 2 or 3 TECU. Radar systems require uncertainties of 5 TECU. The $TEC_{overhead}$ is expected to contibute several TECU to any NPOESS-based determination of TEC (vertical) in 40.8.5-2. Thus, the uncertainties associated with the fractional contribution of these overhead measurements should be consistent with the overall uncertainties assigned to TEC (vertical) in 40.8.5-22. The Measurement Uncertainty for $TEC_{overhead}$ also supports future CONOPS for objective measurements of the EDP at altitudes above the satellite (40.8.5-13, objective).

EDR 40.8.5
Electron Density Profile

Paragraph No.	40.8.5-31
Parameter	h.3. Measurement Uncertainty – Feature - Ion Composition

Threshold	N/A
Clarification	This is an objective parameter.
Objective	5% of the local density, n_e
Clarification	This objective Measurement Uncertainty will help constrain assimilative ionospheric models in future CONOPS supporting HF Comm, Navigation, Space Surveillance Systems, and National Program Users. In general, this parameter will result in a more accurate determination of the topside EDP. The ability for the SESS to distinguish the dominant ion species over the full vertical coverage range for the EDP (40.8.5-13) is instrument dependent. So too is a determination of the uncertainty associated with the measurement. The contractor should review and comment on the the nominal value of the objective Measurement Uncertainty for Ion Composition.

EDR 40.8.5
Electric Density Profile

Paragraph No.	40.8.5-32
Parameter	i. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.6
Geomagnetic Field

Description: In-situ measurements of the geomagnetic field. This measurement will likely be made by a vector magnetometer with measurement uncertainty on the order of 1 nT in each component. Spacecraft magnetic fields will have to be minimized, and the instrument's attitude will have to be accurately determined. The timing of the measurements and the location of the spacecraft will also have to be well known. There are many engineering tradeoffs to be considered by the TSPR here, so the accuracy and precision of the entire instrument-spacecraft system rather than that of the magnetometer are specified here.

Usage: The primary use of this data is to support the periodic (5-year) updates to the World Magnetic Model (WMM), Mil-W-89500. The needs of the WMM require a well calibrated vector magnetometer over the duration of the mission. A secondary use of the data is to detect transients (spatial and temporal) in the earth's field due to magnetic field-aligned currents. Field-aligned current characterization is useful for magnetospheric specification models.

EDR 40.8.6
Geomagnetic Field

Other Comments:

In-situ measurements of the geomagnetic field are obtained primarily to support updates to the World Magnetic Model (WMM). Secondary uses include the analysis of spatial and temporal transients in the geomagnetic field due to field-aligned currents, used to assess the state of the magnetosphere and its impact on the ionosphere. The WMM requires the greatest accuracy and so drives this EDR specification.

The WMM is used for navigation and other purposes by DOD and others. The WMM is required to provide the horizontal and vertical components of the magnetic field at sea level to within 200 nT on a root mean square basis, worldwide, over the lifetime of the model (5 years). Small scale crustal fields cause the actual field to deviate from the WMM on average by roughly 90 nT and secular variations cause the model to deviate by roughly 35 nT by the end of the five-year lifetime of the model. Subtracting these values from 200 nT leaves the requirement that the model represent the large-scale internal field of the Earth to within 75 nT at sea level.

Measurements on-orbit of the Earth's internal field suffer an average contamination of roughly 10 nT due to crustal fields and 30 nT due to ionospheric currents. This leaves a requirement to measure the in-situ field to within 35 nT. (One might suggest that such uncertainties should be combined in quadrature, but some are not random and some are not gaussian distributed. In the absence of a careful analysis of these issues we will

EDR 40.8.6
Geomagnetic Field

Other Comments (continued):

simply add them.) Since a 100-m horizontal reporting interval is required and 50 nT/km field gradients can be expected it is required that the spacecraft-magnetometer system measure the in-situ field to within roughly 30 nT.

An earlier specification discussed individual contributions to the overall uncertainty in detail. Specifically, magnetometer uncertainty, contamination from spacecraft magnetic fields, as well as uncertainties in spacecraft location, time of measurement, detector attitude, and field component non-simultaneity. A scalar magnetometer was also specified in order to calibrate the vector magnetometer. It was felt that a more efficient procedure would be to allow the TSPR to address the complex engineering tradeoffs involved, since many spacecraft characteristics are involved.

Though there are many assumptions and rough estimates going into this analysis, there is considerable user experience constructing the WMM. User input was given heavy consideration throughout and there is confidence that the required precision and accuracy are sufficient to the task.

EDR 40.8.6
Geomagnetic Field

		Threshold	Objective
40.8.6-1	a. Measurement Range (per axis)	0 to ±60,000 nT	0 to ±60,000 nT
40.8.6-2	b. Measurement Accuracy (per axis)	5 nT	2 nT
40.8.6-3	c. Measurement Precision (per axis)	30 nT	[*TBD*]
40.8.6-4	d. Deleted		
40.8.6-5	e. Horizontal Cell Size	100 m	100 m
40.8.6-6	f. Horizontal Coverage	Global	Global
40.8.6-7	g. Horizontal Reporting Interval	1 km	0.1 km
	h. Deleted		
40.8.6-8	1. Deleted		
40.8.6-9	2. Deleted		
40.8.6-10	i. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-1
Parameter	a. Measurement Range (per axis)
Threshold	0 to ±60,000 nT
Clarification	The Earth's magnetic field varies up to roughly 50,000 nT on orbit and is below 60,000 nT on most of the Earth's surface.
Objective	0 to ±60,000 nT
Clarification	Objective is the same as threshold.

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-2
Parameter	b. Measurement Accuracy (per axis)

Threshold	5 nT
Clarification	This is the accuracy with which the in-situ magnetic field can be extracted from the instrument-spacecraft system. A magnetometer much more accurate than this will likely be required since errors due to spacecraft fields, instrument pointing uncertainty, instrument calibration, etc., will impact the measurement. Here, accuracy refers to the DC contributions to measurement uncertainty.
Objective	2 nT
Clarification	The primary user for these data would like the absolute calibration of the sensor to be as accurate as possible.

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-3
Parameter	c. Measurement Precision (per axis)

Threshold	30 nT
Clarification	This is the precision with which the in-situ magnetic field can be extracted from the instrument-spacecraft system. A magnetometer much more precise than this will likely be required since errors due to spacecraft fields, instrument pointing uncertainty, etc., will impact the measurement. Here, precision refers to the AC contributions to measurement uncertainty.
Objective	[*TBD*]
Clarification	The primary user for these data would like it to be as clean as possible.

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-5
Parameter	e. Horizontal Cell Size
Threshold	100 m
Clarification	Appreciable gradients in the magnetic field begin to degrade the usefulness of measurements for cell sizes larger than 100 m. Gradients of 50 nT per km can occur, contributing uncertainties of roughly 5 nT to the analysis, for a 100-m cell size.
Objective	100 m
Clarification	Objective is the same as threshold.

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-6
Parameter	f. Horizontal Coverage

Threshold	Global
Clarification	The World Magnetic Model's coverage is global, so it requires globally distributed data.
Objective	Global
Clarification	Objective is the same as threshold.

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-7
Parameter	g. Horizontal Reporting Interval

Threshold	1 km
Clarification	While the main field being modeled here varies slowly, many of the contaminants vary on small spatial and temporal scales requiring a high degree of data redundancy for their removal.
Objective	.1 km
Clarification	Full coverage would better provide for the removal of small-scale effects.

EDR 40.8.6
Geomagnetic Field

Paragraph No.	40.8.6-10
Parameter	i. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage “store and dump” communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.9
In-situ Plasma Fluctuations

Description: In-situ measurement of plasma density fluctuations. The desired products are: 1) the mean plasma density, 2) the RMS value of $\delta n/n$, and 3) the spectral index for the fluctuation spectrum, calculated from measurements made over a range of ionospheric scale sizes. These parameters are used to estimate C_kL, the height-integrated irregularity strength parameter, which is an input to ionospheric scintillation models (see EDR 40.8.11).

Usage: This EDR supports DOD requirements for knowledge of the presence of ionospheric scintillation activity in both the low and high latitudes. The observed fluctuations may be used to infer the presence of “equatorial bubbles” and polar-cap patches and auroral blobs in these regions. In the low latitudes, measurements during the post-sunset to midnight time period are of greatest interest.

EDR 40.8.9
In-situ Plasma Fluctuations

		Threshold	Objective
40.8.9-1	a. Horizontal Reporting Interval	50 km	10 km
40.8.9-2	b. Horizontal Coverage	Global	Global
	c. Measurement Range		
40.8.9-3	1. Mean plasma density	$5x10^3$ to $5x10^6$ cm^{-3}	10^2 to 10^7 cm^{-3}
40.8.9-4	2. Fluctuations scale length	5 to 10^4 m	5 to 10^4 m
40.8.9-5	3. Spectral index	1 to 5	1 to 5
40.8.9-6	4. $\delta n/n$	10^{-2} to 1	10^{-2} to 1
	d. Measurement Uncertainty		
40.8.9-7	1. Mean plasma density	Greater of {20%, $5x10^4$ cm^{-3}}	Greater of {5%, $2x10^2$ cm^{-3}}
40.8.9-8	2. Deleted		
	e. Measurement Precision		
40.8.9-9	1. Spectral index	0.2	0.1
40.8.9-10	2. $\delta n/n$	10^{-2}	10^{-2}
40.8.9-11	f. Deleted		
40.8.9-12	g. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-1
Parameter	a. Horizontal Reporting Interval

Threshold	50 km
Clarification	Derived from natural sizes of ionospheric density structure in the low latitude and at high latitudes (see also EDRs 40.8.5 & 40.8.9). Equatorial irregularities are highly elongated density “bubble” structures, 2000-to-3000 km, aligned to the magnetic north-south direction. These elongated bubbles have typical east-west dimensions of 200-to-300 km and are spaced 50-to-100 km apart. The threshold Horizontal Reporting Interval will help to resolve regions of scintillation. At high latitudes, auroral blobs and polar cap patches are fairly narrow, 200-to-300 km, in the dawn-dusk direction so that this threshold dimension is, again, appropriate.
Objective	10 km
Clarification	Provides improved resolution of polar-cap patches and auroral blobs, particularly at high latitudes.

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-2
Parameter	b. Horizontal Coverage
Threshold	Global
Clarification	Both high & low latitude observations are desired.
Objective	Global
Clarification	Objective is the same as the threshold.

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-3
Parameter	c.1. Measurement Range: Mean Plasma Density

Threshold	5×10^3 to 5×10^6 cm^{-3}
Clarification	This is the range of plasma densities at NPOESS altitudes that roughly corresponds to cases of moderate to strong scintillation activity.
Objective	10^2 to 10^7 cm^{-3}
Clarification	Full range of geophysically occurring densities at NPOESS, including extremes encountered during great magnetic storms.

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-4
Parameter	c.2. Measurement Range: Fluctuation Scale Length

Threshold	5 to 10^4 m
Clarification	This is the range of scale sizes over which the in-situ fluctuations should be measured in order to ensure that one can fully determine the fluctuation spectrum. This is required to identify the plasma instability processes that cause the plasma fluctuations and their evolution.
Objective	5 to 10^4 m
Clarification	Objective is the same as the threshold.

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-5	
Parameter	c.3. Measurement Range: Spectral Index	
Threshold	1 to 5	
Clarification	This is the range of geophysically occurring values.	
Objective	1 to 5	
Clarification	Objective is the same as the threshold.	

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.		40.8.9-6
Parameter		c.4. Measurement Range: $\delta n/n$
Threshold	10^{-2} to 1	
Clarification	Scintillation activity will be insignificant for lower levels of fluctuations. The lower limit of 10^{-2} corresponds to a level immediately above the geophysical noise fluctuations in plasma density. The upper limit of 1 corresponds to the saturuation level of plasma instabilities in the topside ionosphere.	
Objective	10^{-2} to 1	
Clarification	Objective is the same as the threshold.	

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-7
Parameter	d.1. Measurement Uncertainty: Mean plasma density

Threshold	Greater of {20%, $5x10^4$ cm^{-3}}
Clarification	Mean density is required to enable estimation of scintillation strength from in-situ fluctuations. Scintillation strength increases with mean density. Value changed to be consistent with 40.8.9-3 (Measurement Range, Mean plasma density. Note: For a given $\delta n/n$, the scintillation magnitude (sigma phi) increases linearly with mean density but the intensity scintillation magnitude will first increase linearly up to S_4=0.5 and will then change non-linearly to its saturation value around 1.2 to 1.5.
Objective	Greater of {5%, $2x10^2$ cm^{-3}}
Clarification	Allows for more accurate determination of scintillation levels.

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.		40.8.9-9
Parameter		e.1. Measurement Precision: Spectral Index
Threshold	0.2	
Clarification	The spectral index should be measured with sufficient accuracy to adequately characterize the fluctuation spectrum for the purposes of scintillation specification. Note: This refers to the precision with which a best fit straight line to an FFT spectrum can be obtained. Consider a typical in-situ spectral index of 2, and the scale-length range of 10 m to 1 km (scintillation scale). Then, with a precision of 0.2 for the spectral index, we obtain a 10% precision in the power spectral index at 1 km.	
Objective	0.1	
Clarification	The decibel accuracy of power spectral densities will be more accurate which will provide scintillation specification with higher precision.	

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-10
Parameter	e.2. Measurement Precision: $\delta n/n$

Threshold	10^{-2}
Clarification	The fluctuation level should be measured with sufficient accuracy to adequately characterize the amplitude of the fluctuation spectrum for the purposes of scintillation prediction. The threshold requirement will match the lowest limit of dn/n; 1% density fluctuations with a plasma density of 10^6 cm^{-3} will provide moderate VHF scintillation.
Objective	10^{-2}
Clarification	Objective is the same as the threshold.

EDR 40.8.9
In-situ Plasma Fluctuations

Paragraph No.	40.8.9-12
Parameter	g. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.10
In-situ Plasma Temperature

Description: This EDR calls for in-situ determinations of the electron and ion temperatures. Plasma temperatures are used in physics-based algorithms to calculate the plasma scale height, plasma diffusion coefficients, airglow and dayglow emission rates, heating effects in the ionosphere from low-energy electron precipitation. These data will also be usd in coupled Ionospheric-Thermospheric models to estimate neutral temperatures and neutral density composition changes.

Usage: There are several models and algorithms that use or will use these data. Presently, in-situ plasma temperatures are an input to PRISM, the operational real-time assimilation model that calculates electron density profiles. In the near future, this EDR will be used within specific algorithms that specify and forecast equatorial scintillation. These algorithms are presently developed for the C/NOFS mission, and will be applicable to DMSP and NPOESS data. Other applications of the plasma temperatures are related to airglow calculations. Several reaction rates depend on the plasma temperature. Most reaction rates that are relevant to the estimates of the electron and neutral density profiles from optical observations do not directly depend on the in-situ temperatures. However, the temperatures can be used to constrain the temperature-dependent altitude models used in the calculation of the reaction rates. At high latitudes future CONOPS will also use the plasma temperature to calculate the neutral temperature, and, from it, satellite drag. These algorithms will be of particular importance when calculating the neutral temperature during magnetic storms when Joule heating modifies the neutral density profiles.

EDR 40.8.10
In-situ Plasma Temperature – T_e & T_i

		Threshold	Objective
40.8.10-1	a. Horizontal Reporting Interval	@Horizontal Cell Size	@Horizontal Cell Size
40.8.10-2	b. Horizontal Coverage	Global	Global
40.8.10-3	c. Measurement Range	500 – 10,000 ^oK	500 – 10,000 ^oK
40.8.10-4	d. Measurement Uncertainty	10%	5%
40.8.10-5	e. Latency (Data Latency)	90 minutes	15 minutes
	f. Horizontal Cell Size		
40.8.10-6	1. Latitudes: 0-30^o, N/S	100 km	10 km
40.8.10-7	2. Latitudes: 30-90^o, N/S	50 km	10 km

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.	40.8.10-1
Parameter	a. Horizontal Reporting Interval
Threshold	@ Horizontal Cell Size
Clarification	The threshold requirement calls for sequential reports of this EDR at the resolution of the threshold Horizontal Cell Size (HCS) ; that is, one data record per HCS increment. Reference is made to the HCS parameters in 40.8.4-5 and –6. In practice, the Horizontal Reporting Interval will be one measurement per report.
Objective	@ Horizontal Cell Size
Clarification	The objective parameter corresponds to the objective HCS.

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.	40.8.10-2
Parameter	b. Horizontal Coverage
Threshold	Global
Clarification	The threshold requirement is for global estimates of this EDR. These data support emerging and future CONOPS which require a specification of the EDP at all geographic locations.
Objective	Global
Clarification	Objective paralmeter is the same as the threshold requirement.

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.		40.8.10-3
Parameter		c. Measurement Range
Threshold	500 – 10,000 °K	
Clarification	The threshold range is sufficient to include the electron and ion temperatures at NPOESS altitudes under all geophysical conditions. The in-situ electron and ion temperatures can be used to constrain ionospheric models used in emerging and future CONOPS supporting HF Comm, Navigation, Space Surveillance Radars, and National Programs. This parameter also has an implicit applicability in coupling the ionosphere to the thermosphere in future neutral density modeling efforts that address the Neutral Density Profile EDR (40.8.12).	
Objective	500 – 10,000 °K	
Clarification	The threshold requirement provides for an adequate measurement range to satisfy all projected user needs.	

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.	40.8.10-4
Parameter	d. Measurement Uncertainty

Threshold	10%
Clarification	The threshold requirement specifies the maximum uncertainty in each of the estimates for electron and ion temperatures that are used in ionospheric modeling efforts. See 40.8.10-3 for the list of the possible future CONOPS supported by the In-situ Plasma Temperature EDR. This error may also constrain the EDP EDR (40.8.5).
Objective	5%
Clarification	The objective value for this parameter may provide improved accuracies in user CONOPS and permit a more precise determination of the EDP within the topside F region.

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.	40.8.10-5
Parameter	e. Latency (Data Latency)
Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage “store and dump” communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.	40.8.10-6	
Parameter	f.1. Horizontal Cell Size – Latitudes 0-30° N/S	
Threshold	100 km	
Clarification	The threshold requirement for Horizontal Cell Size is commensurate with the threshold HCS for the EDP EDR (40.8.5). This requirements assigned to the EDP in support of future user CONOPS establish the need for an equatorial resolution of 100 km.	
Objective	10 km	
Clarification	The objective paramenter for HCS is commensurate with the Horizontal Cell Size in EDP EDR (40.8.5).	

EDR 40.8.10
In-situ Plasma Temperature

Paragraph No.	40.8.10-7
Parameter	f.2. Horizontal Cell Size – Latitudes 30-90^{o} N/S

Threshold	50 km
Clarification	The threshold requirement for this parameter is commensurate with the threshold Horizontal Cell Size for the EDP EDR (40.8.5). This requirement assigned to the EDP in support of future user CONOPS establish the need for an auroral/polar region resolution of 50 km. It is specifically noted here that this parameter refers to the auroral and high-latitude ionosphere – within the mid-latitude ionosphere the cell size for this EDR can be relaxed considerably. However, it is suggested that the HCS for this EDR and for the EDP EDR be the same at all times.
Objective	10 km
Clarification	The objective paramenter for HCS is commensurate with the HCS in EDP EDR (40.8.5).

EDR 40.8.11
Ionospheric Scintillation

Description: Ionospheric scintillation, which manifests itself as increased noise on radiowave signal intensity and phase, is caused by small-scale variations in ionospheric electron density along a trans-ionospheric propagation path. The magnitude of the effect depends on the ionospheric background, the amplitude and spectral characteristics of ionospheric density fluctuations, and the frequency involved. Maximum scintillation effects are expected at low magnetic latitudes after sunset and within the nightside auroral zones and polar caps at all times. The requirement is for direct measurement of scintillation parameters in terms of amplitude and phase fluctuation indices, S_4 and σ_φ, respectively, at VHF, UHF, L-band and S-band frequencies. These data will be used in a global specification of scintillation.

Usage: This EDR supports DOD requirements for knowledge of the presence of ionospheric scintillation activity in both the low and high latitudes. The observed fluctuations may be used to infer the presence of "equatorial bubbles" and polar-cap patches and auroral blobs in these regions.

EDR 40.8.11
Ionospheric Scintillation

		Threshold	Objective
40.8.11-1	a. Horizontal Cell Size	50 km	10 km
40.8.11-2	b. Horizontal Coverage	Global	Global
	c. Measurement Range		
40.8.11-3	1. S_4	0.1 to 1.5	0.1 to 1.5
40.8.11-4	2. sigma-ϕ	0.1 to 20 radians	0.1 to 20 radians
	d. Measurement Uncertainty		
40.8.11-5	1. S_4	0.1	0.1
40.8.11-6	2. sigma-ϕ	0.1 radians	0.1
40.8.11-7	e. Local Time Range	All local times	All local times
40.8.11-8	f. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.		40.8.11-1
Parameter		a. Horizontal Cell Size
Threshold	50 km	
Clarification	Derived from natural sizes of ionospheric density structures at low latitudes and high latitudes (see also EDRs 40.8.5 & 40.8.9). Equatorial irregularities are highly elongated density “bubble” structures, 2000-to-3000 km, aligned to the magnetic north-south direction. These elongated bubbles have typical east-west dimensions of 200-to-300 km and are spaced 50-to-100 km apart. The threshold horizontal cell size will help to resolve regions of scintillation. At high latitudes, auroral blobs and polar-cap patches are fairly narrow, 200-to-300 km, in the dawn-dusk direction so that this threshold dimension is, again, appropriate.	
Objective	10 km	
Clarification	Provides improved resolution of polar-cap patches and auroral blobs, particularly in the high latitudes.	

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-2
Parameter	b. Horizontal Coverage
Threshold	Global
Clarification	Both high & low latitude observations are the primary regions of interest; however, global coverage provides assured knowledge especially during severe magnetic storms when L-band systems, such as the FAA's WAAS, become affected by scintillation in the sub-auroral and mid-latitude regions.
Objective	N/A
Clarification	Objective is the same as threshold.

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-3
Parameter	c.1. Measurement Range: S_4

Threshold	0.1 – 1.5
Clarification	This is the naturally occurring range over which scintillation can have a significant impact at VHF, UHF, L-Band, and S-band frequencies.
Objective	0.1 – 1.5
Clarification	Objective is the same as the threshold.

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-4
Parameter	c.2. Measurement Range: σ_φ

Threshold	0.1 to 20 radians
Clarification	The threshold value is the naturally occurring range over which scintillation can have a significant impact at UHF, L-Band, and S-band frequencies. The determination of σ_φ should be made relative to a detrend interval of 10 seconds.
Objective	0.1 to 20 radians
Clarification	Objective is the same as the threshold.

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-5	
Parameter	d.1. Measurement Uncertainty: S_4	

Threshold	0.1
Clarification	This threshold value is most relevant for weak scintillations. For the moderate to strong scintillation (12 dB) that have the greatest operational impact, 2 dB (or S_4=0.1) this threshold is quite adequate. There is no need to measure S_4 more precisely, as scintillation does not have a substantially different operational impact within this uncertainty.
Objective	0.1
Clarification	Objective is the same as the threshold.

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-6
Parameter	d.2. Measurement Uncertainty: σ_{φ}

Threshold	0.1 radians
Clarification	There is no need to measure phase scintillation more precisely, as scintillation does not have a substantially different operational impact within this uncertainty. The Measurement Uncertainty for σ_{φ} should be referenced to a detrend interval of 10 seconds.
Objective	0.1 radians
Clarification	Objective is the same as the threshold.

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-7
Parameter	e. Local Time Range

Threshold	All local times
Clarification	This threshold requirement is specified as "All local times" to satisfy the [TBS] requirement in the IORD-1A. The requirement has limited applicability. In general, NPOESS should provide continuous measurements of Ionospheric Scintillation. It is recognized however, that the predominant occurrences of Ionospheric Scintillation are in the evening to nightside sector (1800-0600 local time, normally; 1800-1200 in the extreme) at low-latitudes (below 40^{o} geographic) low-latitude and at all local times within the auroral zone.
Objective	All local times
Clarification	Objective is the same as threshold.

EDR 40.8.11
Ionospheric Scintillation

Paragraph No.	40.8.11-8
Parameter	f. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.12 Neutral Density Profile

Description: The Neutral Density Profile (NDP) EDR is the specification of the average neutral density at the set of discrete altitudes within the specified ranges. Each NDP EDR can be derived from measurements and local models that, at all altitudes, are within the specified uncertainties. The EDR for the NDP provides a *local average revisit time* of 12 hours. Profiles are to be used, along with other geophysical quantities, as inputs to upper atmospheric density models.

Usage: This EDR supports DOD needs to accurately specify and forecast the atmospheric neutral density for Space Surveillance. The DOD requirements for neutral density profile are derived from a validated US/AF Space Command requirement to specify the total atmospheric density within a given range of altitudes. The requirements specify an altitude-dependent threshold uncertainty between 10% and 20%. The associated objective uncertainty is between 5% and 15%. Meeting the threshold uncertainty requirement at all times, including geomagnetic storms, presumes the use of a front-end assimilative model that uses a combination of neutral density maps and satellite tracking data to optimally constrain the predictions of operational empirical density models. Meeting the objective uncertainty requirement presumes use of assimilative first-principles modeling. This EDR also supports DOC requirements for spacetrack predictions.

EDR 40.8.12
Neutral Density Profile

		Threshold	Objective
40.8.12-1	a. Horizontal Cell Size	500 km	250 km
40.8.12-2	b. Horizontal Reporting Interval	500 km	250 km
	c. Vertical Cell Size		
40.8.12-3	1. Up to 120 km	5 km	0.5 km
40.8.12-4	2. Above 120 km	5 km	3 km
	d. Vertical Reporting Interval		
40.8.12-5	1. < 120 km	5 km	2.5 km
40.8.12-16	2. 120 to 200 km	10 km	5 km
40.8.12-17	3. > 200 km	30 km	15 km
40.8.12-6	e. Horizontal Coverage	Global	Global
40.8.12-7	f. Vertical Coverage	90 km to satellite altitude	90 to 1600 km
	g. Measurement Range		
40.8.12-8	1. Atmospheric density	8.5×10^{-18} to 5×10^{-9} g cm^{-3}	2×10^{-19} to 5×10^{-9} g cm^{-3}
40.8.12-9	2. Number density	10^6 to 6×10^{13} cm^{-3}	9×10^4 to 6×10^{13} cm^{-3}
40.8.12-10	3. Neutral Composition	N/A	N_2, O_2, O, He, H

Continued on next slide

EDR 40.8.12
Neutral Density Profile

continued

		Threshold	Objective
	h. Measurement Uncertainty (Density)		
40.8.12-11	1. 90 to 500 km	10%	5%
40.8.12-12	2. 500 to 700 km	15%	10%
40.8.12-13	3. 700 to 800 km	20%	
40.8.12-18	4. 700 to 1600 km		15%
40.8.12-14	i. Measurement Precision	5%	1%
40.8.12-15	j. Latency (Data Latency)	90 minutes	15 minutes
	k. Altitude Registration		
40.8.12-19	1. 90 to 500 km	1 km	0.5 km
40.8.12-20	2. 500 to 700 km	1.5 km	1 km
40.8.12-21	3. 700 to 800 km	2 km	
40.8.12-22	4. 700 to 1600 km		1.5 km

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-1
Parameter	a. Horizontal Cell Size
Threshold	500 km
Clarification	There are known inherent errors in empirical density models and the processing used to apply neutral density information to these models. 500 km horizontal cell size was chosen such that the measurements are resolved enough to allow threshold uncertainty values to be obtained when these measurements are used with operational empirical density models.
Objective	250 km
Clarification	Wave structures with scale sizes below 500 km and amplitudes in excess of 10% can occur, particularly during geomagnetic storms. 250 km horizontal cell size is needed to be able to adequately detect and represent these localized structures and input into a global first-principles model to obtain neutral density to within 5% uncertainty.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-2
Parameter	b. Horizontal Reporting Interval

Threshold	500 km
Clarification	There are known inherent errors in empirical density models and the processing used to apply neutral density information to these models. 500 km horizontal cell size was chosen such that the measurements are resolved enough to allow threshold uncertainty values to be obtained when these measurements are used with operational empirical density models.
Objective	250 km
Clarification	Wave structures with scale sizes below 500 km and amplitudes in excess of 10% can occur, particularly during geomagnetic storms. 250 km horizontal cell size is needed to be able to adequately detect and represent these localized structures and input into a global first-principles model to obtain neutral density to within 5% uncertainty.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-3	
Parameter	c.1. Vertical Cell Size – up to 120 km	
Threshold	5 km	
Clarification	The cell size required to constrain the resolution errors to be less than the allowed uncertainties depends on scale height, with smaller cell sizes required for smaller scale heights. The 5 km cell size is sufficient to give required uncertainty for all scale heights in the part of the high drag regime (< 800 km) where satellites operate.	
Objective	0.5 km	
Clarification	This cell size is needed in order for global first-principles models to obtain neutral density to within 5% uncertainty.	

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-4
Parameter	c.2. Vertical Cell Size – above 120 km

Threshold	5 km
Clarification	The cell size required to constrain the resolution errors to be less than the allowed uncertainties depends on scale height, with smaller cell sizes required for smaller scale heights. The 5 km cell size is sufficient to give required uncertainty for all scale heights in the part of the high drag regime (< 800 km) where satellites operate.
Objective	3 km
Clarification	This cell size is needed in order for global first-principles models to obtain neutral density to within 5% uncertainty.

EDR 40.8.12
Neutral Density Profile

Paragraph No.		40.8.12-5
Parameter		d.1. Vertical Reporting Interval - <120 km
Threshold	5 km	
Clarification	A vertical reporting interval of ~1 scale height is required as input into models to obtain neutral density to within 10% uncertainty.	
Objective	2.5 km	
Clarification	A vertical reporting interval of ~½ scale height is required as input into global first-principles models to obtain neutral density to within 5% uncertainty.	

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-16
Parameter	d.2. Vertical Reporting Interval – 120 to 200 km

Threshold	10 km
Clarification	A vertical reporting interval of ~1 scale height is required as input into models to obtain neutral density to within 10% uncertainty.
Objective	5 km
Clarification	A vertical reporting interval of ~½ scale height is required as input into global first-principles models to obtain neutral density to within 5% uncertainty.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-17
Parameter	d.3. Vertical Reporting Interval - > 200 km
Threshold	30 km
Clarification	A vertical reporting interval of ~1 scale height is required as input into models to obtain neutral density to within 10% uncertainty.
Objective	15 km
Clarification	A vertical reporting interval of ~½ scale height is required as input into global first-principles models to obtain neutral density to within 5% uncertainty.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-6
Parameter	e. Horizontal Coverage

Threshold	Global
Clarification	This is derived from a USAF Space Command documented requirement for atmospheric neutral density predictions to occur at all latitudes and longitudes.
Objective	Global
Clarification	Objective is the same as the threshold.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-7
Parameter	f. Vertical Coverage

Threshold	90 km – satellite altitude
Clarification	The low end of the altitude band is from a USAF Space Command documented requirement for atmospheric neutral density predictions to occur at altitudes of 90 to 1500 km. This value covers the lowest altitude at which satellites may fly before re-entry. For the upper bound, satellite drag has its greatest effect on objects flying lower than 800 km. AF Space Command Directorate of Operations Analysis DCS/Operations Density Accuracy Sensitivity Study conclusions state that, for satellites with an altitude above 800km, a neutral density error of 20% only introduces minor propagation error that does not impact existing operations.
Objective	90 – 1600 km
Clarification	The upper bound is reflected by the top of US/AF Space Command's altitude of interest extended by 100 km (from 1500 km to 1600 km) to be consistent with ionospheric modeling and coupling requirements.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-8
Parameter	g.1. Measurement Range – Atmospheric Density

Threshold	8.8×10^{-18} to 5×10^{-9} g cm^{-3}
Clarification	The values given correspond to typical values for neutral mass density nea 850 km (satellite altitude) and 90 km, respectively.
Objective	2×10^{-19} to 5×10^{-9} g cm^{-3}
Clarification	The values given correspond to typical values for neutral mass density at 1600 km and 90 km, respectively.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-9
Parameter	g.2. Measurement Range – Number Density
Threshold	10^6 to $6x10^{13}$ cm^{-3}
Clarification	The values given correspond to typical values for neutral number density at 850 km (satellite altitude) and 90 km respectively. Both mass and number density are specified to be consistent with the IORD.
Objective	$9x10^4$ to $6x10^{13}$ cm^{-3}
Clarification	The values given correspond to typical values for neutral number density at 1600 km and 90 km respectively.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-10	
Parameter	g.3. Neutral Composition	
Threshold	N/A	
Clarification	There is a challenge in meeting the specified uncertainty requirements throughout the altitude range with current technology. Present instruments can remotely sense altitudes between ~180 and 350 km. The rest of the profile may possibly be extrapolated from the remotely-sensed data. By providing an in-situ measurement of total density at NPOESS altitude, an interpolation scheme could be used to provide better accuracy at altitudes above 350 km. However, since the amount of uncertainty improvement obtained using this technique is unknown, the measurement of neutral composition was left as an objective requirement.	
Objective	N_2, O_2, O, He, H	
Clarification	These are the constituents of the neutral atmosphere at the specified altitude range. Individual composition information is needed to meet the objective requirement of 5% density uncertainty through use of first-principles multi-constituent models.	

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-11
Parameter	h.1. Measurement Uncertainty (Density) – 90 to 500 km

Threshold	10%
Clarification	AF Space Command provided these uncertainty values to the NPOESS IPO. The operational need during the NPOESS era is to improve propagation uncertainty caused by neutral density errors. Since past studies have shown that the average neutral density error for all known empirical density models is about 15%, the numbers stated provide improvement in the low-altitude range and during geomagnetic storms when the uncertainty in the current empirical models rises considerably.
Objective	5%
Clarification	These values are taken directly from the US/AF Space Command documented requirement for atmospheric neutral density predictions. NPOESS measurements can be no worse than user-specified uncertainties.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-12
Parameter	h.2. Measurement Uncertainty (Density) – 500 to 700 km

Threshold	15%
Clarification	AF Space Command provided these uncertainty values to the NPOESS IPO. The operational need during the NPOESS era is to improve propagation uncertainty caused by neutral density errors. Since past studies have shown that the average neutral density error for all known empirical density models is about 15%, the numbers stated provide improvement in the low-altitude range and during geomagnetic storms when the uncertainty in the current empirical models rises considerably.
Objective	10%
Clarification	These values are taken directly from the USAF Space Command documented requirement for atmospheric neutral density predictions. NPOESS measurements can be no worse than user-specified uncertainties.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-13
Parameter	h.3. Measurement Uncertainty (Density) – 700 to 800 km

Threshold	20%
Clarification	AF Space Command provided these uncertainty values to the NPOESS IPO. The operational need during the NPOESS era is to improve propagation uncertainty caused by neutral density errors. Since past studies have shown that the average neutral density error for all known empirical density models is about 15%, the numbers stated provide improvement in the low-altitude range and during geomagnetic storms when the uncertainty in the current empirical models rises considerably.
Objective	
Clarification	

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-21
Parameter	h.4. Measurement Uncertainty (Density) – 700 to 1600 km

Threshold	
Clarification	
Objective	15%
Clarification	These values are taken directly from the USAF Space Command documented requirement for atmospheric neutral density predictions. NPOESS measurements can be no worse than user-specified uncertainties.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-14
Parameter	i. Measurement Precision

Threshold	5%
Clarification	The measurement precision needs to be less than the specified uncertainty values. The neutral density measurements must be of sufficient repeatability to adequately constrain the empirical model.
Objective	1%
Clarification	The measurement precision needs to be less than the specified uncertainty values. This capability for repeatability of measurement is needed for first-principles models to yield objective uncertainties.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-22
Parameter	j. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage “store and dump” communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-19
Parameter	k.1. Altitude Registration – 90 to 500 km

Threshold	1 km
Clarification	Since the scale height increases with altitude in the thermosphere, a looser altitude registration is acceptable at higher altitudes. Density changes by about 12%/km at 120 km, 3%/km at 200 km, and 2%/km at 300 km. The neutral density measurements must be registered accurately to altitude in order to obtain specified uncertainties.
Objective	0.5 km
Clarification	The neutral density measurements must be registered accurately to altitude in order to obtain specified uncertainties. The error budget must be within the 5% range when inputting the data into first-principles models.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-20
Parameter	k.2. Altitude Registration – 500 to 700 km

Threshold	1.5 km
Clarification	Since the scale height increases with altitude in the thermosphere, a looser altitude registration is acceptable at higher altitudes. Density changes by about 12%/km at 120 km, 3%/km at 200 km, and 2%/km at 300 km. The neutral density measurements must be registered accurately to altitude in order to obtain specified uncertainties.
Objective	1 km
Clarification	The neutral density measurements must be registered accurately to altitude in order to obtain specified uncertainties. The error budget must be within the 5% range when inputting the data into first-principles models.

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-21
Parameter	k.3. Altitude Registration – 700 to 800 km

Threshold	2 km
Clarification	Since the scale height increases with altitude in the thermosphere, a looser altitude registration is acceptable at higher altitudes. Density changes by about 12%/km at 120 km, 3%/km at 200 km, and 2%/km at 300 km. The neutral density measurements must be registered accurately to altitude in order to obtain specified uncertainties.
Objective	
Clarification	

EDR 40.8.12
Neutral Density Profile

Paragraph No.	40.8.12-22
Parameter	k.4. Altitude Registration – 700 to 1600 km
Threshold	
Clarification	
Objective	1.5 km
Clarification	The neutral density measurements must be registered accurately to altitude in order to obtain specified uncertainties. The error budget must be within the 5% range when inputting the data into first-principles models.

EDR 40.8.13
Medium Energy Charged Particles

Description: Measurements of particles in this energy range are required to serve as inputs to models of the auroral ionosphere, determine the boundaries and extent of the polar cap, and provide inputs to magnetospheric models. These data are also used in the analysis of satellite anomalies involving surface charging and, at the higher energies, deep-dielectric charging and radiation damage. The requirement is for the energy distribution of both ions and electrons within the specified energy ranges. Particle measurements are required over a range of pitch angles both inside and external to the local loss cone.

Usage: These measurements support the International Space Station and other NASA missions (Hubble Space Telescope) by providing the locations and intensities of enhanced radiation, assist in the analysis of system anomalies, provide situational awareness of the state of the radiation environment for operational planning, and supply required data to assess the level of ionospheric disturbances during geomagnetic and solar storms.

EDR 40.8.13
Medium Energy Charged Particles

		Thresholds	Objectives
40.8.13-1	a. Horizontal Reporting Interval	25 km	10 km
	b. Measurement Range		
40.8.13-2	1. Energy - ions	50 keV to 10 MeV	50 keV to 10 MeV
40.8.13-13	2. Energy - electrons	50 keV to 4 MeV	50 keV to 4 MeV
40.8.13-3	3. Total Flux	10^6 – $5x10^{11}$ m^{-2} s^{-1} $ster^{-1}$	$5x10^5$ – $2x10^{12}$ m^{-2} s^{-1} $ster^{-1}$
40.8.13-4	4. Sensor FOV	0^o and 90^o (two angles)	0^o - 90^o (multiple angles)
40.8.13-16	5. Energy Resolution (p+)	6 logarithmically spaced bands	8 logarithmically spaced bands
40.8.13-17	6. Energy Resolution (e-)	5 logarithmically spaced bands	6 logarithmically spaced bands
	c. Measurement Precision		
40.8.13-5	1. Deleted		
40.8.13-6	2. Total flux	Greater of {10^6 m^{-2} s^{-1} $ster^{-1}$, 5%}	Greater of {$5x10^5$ m^{-2} s^{-1} $ster^{-1}$, 1%}
40.8.13-7	3. Sensor FOV	$\leq 30^o$	$\leq 20^o$
	d. Measurement Uncertainty		
40.8.13-8	1. Energy	10%	5%
40.8.13-9	2. Deleted		
40.8.13-10	3. Deleted		

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EDR 40.8.13
Medium Energy Charged Particles

continued

		Thresholds	Objectives
	e. Total Dose		
40.8.13-11	1. Range	N/A	$10^1 – 10^6$ rads/yr
40.8.13-12	2. Moderator Range	N/A	4, 100, 250, 500 mils Al
	f. Measurement Accuracy		
40.8.13-14	1. Total Flux	15%	10%
40.8.13-18	2. Sensor FOV	$\leq 3^o$	$\leq 2^o$
40.8.13-15	g. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-1
Parameter	a. Horizontal Reporting Interval

Threshold	25 km
Clarification	This dimension is ~ twice the gyroradius of the most energetic protons to be measured and sets the maximum scale size for boundaries.
Objective	10 km
Clarification	This dimension is ~ twice the gyroradius of a proton with energy near the midpoint of the energy range and sets the typical scale size for boundaries.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-2
Parameter	b.1. Measurement Range – Energy - ions

Threshold	50 keV to 10 MeV
Clarification	The 50 keV minimum energy is consistent with the high-energy limit for the Supra-thermal through Auroral Partilces EDR in requirement 40.8.16-3. The 10 MeV limit for protons is consistent with the low energy limit for the Energic Ions EDR in requirement 40.8.14-3 and includes the low energy component of the solar energetic proton population.
Objective	50 keV to 10 MeV
Clarification	The threshold energy range covers all energies of interest bounded by the Supra-thermal through Auroral Particles (EDR 40.8.16) and the Energetic Ions (EDR 40.8.14).

Note: Measurements of both electrons and protons (ions) are required as radiation effects are particle-species dependent. Previously, this requirement included the same energy range for electrons and positive ions. However, the flux of electrons greater than 4 MeV is insignificant at NPOESS altitudes.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-13
Parameter	b.2. Measurement Range – Energy - electrons

Threshold	50 keV to 4 MeV for electrons
Clarification	The 50 keV minimum energy is consistent with the high-energy limit for the Supra-thermal through Auroral Partilces EDR in requirement 40.8.16-3. The 4-MeV, high-energy limit for electrons reflects the fact that fluxes of electrons of higher energy are insignificant at the NPOESS orbit.
Objective	50 keV to 4 MeV for electrons
Clarification	There is no need to go beyond the threshold value for this parameter. The low-energy value dovetails nicely with the upper range for the Supra-thermal through Auroral Particles. As noted above, the 4-MeV upper energy limit reflects the fact that fluxes of electrons of higher energy are insignificant at NPOESS altitudes.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-3
Parameter	b.3. Measurement Range – Total Flux
Threshold	10^{6} - 5 x 10^{11} m^{-1} s^{-1} $ster^{-1}$
Clarification	This parameter refers to the integral flux for particles of energy 50 keV and greater. The minimum and maximum integral fluxes are set by NOAA-15 observations during 1998.
Objective	5 x10^{5} – 2 x 10^{12} m^{-1} s^{-1} $ster^{-1}$
Clarification	The maximum integral flux is that for extreme cases during solar maximum. The minimum integral flux will remove ambiguity in knowledge of fluxes during very quiescent periods.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-4
Parameter	b.4. Measurement Range - Sensor FOV

Threshold	0º and 90º (two angles)
Clarification	0º refers to an outward looking sensor radially aligned (nominally) with the earth-satellite vector. The 90º Sensor Viewing Angle is perpendicular to the earth-satellite vector. Directional sensors viewing at these aspect angles will insure that both magnetically mirroring particles and particles within the atmospheric loss cone are separately observed at geographic latitudes >35º
Objective	0º to 90º (multiple angles)
Clarification	The objective provides improved particle pitch angle coverage at all geographic latitudes

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-16
Parameter	b.5. Measurement Range - Energy Resolution (p^+)

Threshold	6 logarithmically spaced bands
Clarification	The effects of radiation are dependent upon particle energy and the flux as a function of energy must be determined.
Objective	8 logarithmically spaced bands
Clarification	Provided for improved energy resolution and characterization of the particle energy spectrum

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-17
Parameter	b.6. Measurement Range - Energy Resolution (e^-)

Threshold	5 logarithmically spaced bands
Clarification	The effects of radiation are dependent upon particle energy and fluxes as a function of energy must be determined.
Objective	6 logarithmically spaced bands
Clarification	Increased energy resolution and better definition of particle energy spectrum

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-6
Parameter	c.2. Measurement Precision – Total flux

Threshold	Greater of {10^6 m^{-2} s^{-1} $ster^{-1,}$, 5%}
Clarification	The threshold requirement for Measurement Precision refers to Poisson counting statistics and the effects of data compression. Specifically, Measurement Precision has to do with how data are treated in-flight – not the quality of the ground calibrations (Measurement Accuracy). It is assumed that the single-count level for the detector is the minimum value for the Measurement Range; that is, 10^6 m^{-2} sec^{-1} $ster^{-1}$ in 40.8.13-3. At low count rates the precision will be dominated by statistics and one cannot ask for 10% precision – only that the difference between 0 and the floor values be recognized. At higher count rates – and we ask for 6 orders of magnitude dynamic range - the statistical uncertainties may be much less than 1% (10,000 counts) but the precision will be dominated by the compression algorithm that is used in the counters. In this case, the compression algorithm should provide a Measurement Precision of less than 5%.
Objective	Greater of {$5x10^5$ m^{-2} s^{-1} $ster^{-1}$, 1%}
Clarification	This provides for more precise determination of variations in particle flux in accordance with the methodology discussed above.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-7
Parameter	c.3. Measurement Precision - Sensor FOV

Threshold	≤30º
Clarification	This refers to the full angle field of view (FOV). A detector FOV no larger than this value is required to separate geomagnetically trapped particles from precipitating particles at latitudes above 35º
Objective	≤20º
Clarification	The smaller FOV permits trapped and precipitating particles to be separated at latitudes below 35º

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-8	
Parameter	d.1. Measurement Uncertainty - Energy	

Threshold	10%
Clarification	This refers to the combined effects of statistical effects, the calibration of the detector system, and in-flight variations in the performance of the detector system (e.g. dead layer effects, radiation degradation, etc).
Objective	5%
Clarification	Less uncertainty in knowledge of particle energy converts to a more reliable determination of the particle energy distribution.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-11
Parameter	e.1. Total Dose - Range

Threshold	N/A
Clarification	Objective parameter only.
Objective	10^1 to 10^6 rads/yr
Clarification	The objective would better define the time integrated radiation dose to electronic components in the NPOESS orbit.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-12
Parameter	e.2. Total Dose - Moderator Range

Threshold	N/A
Clarification	Objective parameter only.
Objective	4, 100, 250, 500 mils Al shielding thickness
Clarification	These shielding thickness' are typical on the protective radiation shielding thickness' for typical space electronic components

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-14
Parameter	f.1. Measurement Accuracy - Total Flux

Threshold	15%
Clarification	This refers to preflight accuracy in the sensor calibration
Objective	10%
Clarification	This provides for more precise determination of particle flux

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-17
Parameter	f.2. Measurement Accuracy - Sensor FOV

Threshold	≤3º
Clarification	The threshold value is the combined effect of sensor mounting accuracy and spacecraft stabilization. It is 10% of the sensor full-angle FOV.
Objective	≤2º
Clarification	The objective provides for a more accurate determination of sensor viewing direction with respect to the local magnetic field.

EDR 40.8.13
Medium Energy Charged Particles

Paragraph No.	40.8.13-15
Parameter	g. Latency (Data Latency)
Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage “store and dump” communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.14
Energetic Ions

Description: Measurements of energetic ions within this energy range are used operationally by the DoC to estimate the location of the polar-cap boundary. The data are also used in post-event assessments of satellite anomalies, semiconductor and solar-cell radiation damage, and radiation hazard to astronauts and aircraft personnel. The data can also be used as input to future operational models of the auroral ionosphere, especially the D-region. The requirement is a measurement of the ion characteristics, including the energy spectrum.

Usage: These measurements support the International Space Station by providing the locations and intensities of enhanced radiation, assist in the analysis of system anomalies, provide situational awareness of the state of the radiation environment for operational planning, and are inputs to advisories of degraded HF communications and the specific locations of that degradation.

EDR 40.8.14
Energetic Ions

		Thresholds	Objectives
40.8.14-1	a. Horizontal Cell Size	25 km	25 km
40.8.14-2	b. Horizontal Coverage	Latitudes >30º N/S	Latitudes >30º N/S
	c. Measurement Range		
40.8.14-3	1. Energy (p^+)	10 MeV to 300 MeV	10 MeV to 400 MeV
	2. Flux, protons		
40.8.14-4	a. < 100 MeV	$5x10^3 – 2x10^9$ m^{-2} s^{-1} $ster^{-1}$	$5x10^3 – 2x10^9$ m^{-2} s^{-1} $ster^{-1}$
40.8.14-13	b. > 100 MeV	$10^3 – 3x10^8$ m^{-2} s^{-1} $ster^{-1}$	$10^3 – 3x10^8$ m^{-2} s^{-1} $ster^{-1}$
40.8.14-5	3. Flux, alphas	N/A	$10^2 – 10^8$ m^{-2} s^{-1} $ster^{-1}$
40.8.14-6	4. Sensor viewing angle	0º	0º
40.8.14-14	5. Lin energy trans (heavy ions)	1 – 50 MeV cm^2 mg^{-1}	0.1 – 100 MeV cm^2 mg^{-1}
40.8.14-19	6. Energy resolution	4 logarithmically spaced bands	5 logarithmically spaced bands
	d. Measurement Precision		
40.8.14-7	1. Deleted		
	2. Flux, protons		
40.8.14-8	a. < 100 MeV	max {$5x10^3$ m^{-2} s^{-1} $ster^{-1}$, 5%}	max {$5x10^3$ m^{-2} s^{-1} $ster^{-1}$, 1%}
40.8.14-15	b. > 100 MeV	max {10^3 m^{-2} s^{-1} $ster^{-1}$, 10%}	max {10^3 m^{-2} s^{-1} $ster^{-1}$, 2%}

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EDR 40.8.14
Energetic Ions

continued

		Thresholds	Objectives
	3. FOV, protons		
40.8.14-9	a. < 100 MeV	<120º full angle	<120º full angle
40.8.14-20	b. > 100 MeV	≤360º full angle	≤360º full angle
	e. Measurement Accuracy		
40.8.14-10	1. Deleted		
	2. Flux, protons		
40.8.14-11	a. < 100 MeV	max {$5x10^3$ m^{-2} s^{-1} $ster^{-1}$, 20%}	max {$5x10^3$ m^{-2} s^{-1} $ster^{-1}$, 10%}
40.8.14-16	b. > 100 MeV	max {10^3 m^{-2} s^{-1} $ster^{-1}$, 10%}	max {10^3 m^{-2} s^{-1} $ster^{-1}$, 2%}
	3. FOV, protons		
40.8.14-12	a. < 100 MeV	<12º	<8º
40.8.14-21	b. > 100 MeV	N/A (isotropic)	N/A (isotropic)
	f. Deleted		
40.8.14-17	1. Deleted		
40.8.14-18	g. Latency (Data Latency)	90 minutes	15 minutes
40.8.14-22	h. Measurement Uncert. - Energy	20%	10%

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-1
Parameter	a. Horizontal Cell Size

Threshold	25 km
Clarification	This horizontal cell size is consistent with the requirement in 40.8.13-1 set by the gyroradius of 10 MeV protons, which is the low energy limit for energetic ions.
Objective	25 km
Clarification	Threshold is the same as the objective.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-2
Parameter	b. Horizontal Coverage

Threshold	>30° Latitude, N/S
Clarification	During extreme solar particle events, energetic ions have been observed at geographic latitudes as low as 30º.
Objective	>30° Latitude, N/S
Clarification	Threshold is the same as the objective. Detecting energetic ions at 30° latitude indicates an extreme level of geomagnetic stress. At such levels maximum precautions must be taken. Therefore, there is no operational benefit for measuring energetic ions below 30° latitude.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-3
Parameter	c.1. Measurement Range – Energy, protons

Threshold	10 MeV to 300 MeV
Clarification	The limit of 10 MeV encompasses the low energy portion of the solar-particle population and provides continuity with the proton energy range specified for Medium Energy Charged Particles, EDR 40.8.13. The limit of 300 MeV encompasses particles that can penetrate heavily shielded spacecraft systems and the atmosphere to aircraft altitudes where they can affect aircraft systems, including the flight crew.
Objective	10 MeV to 400 MeV
Clarification	The increase in energy to 400 MeV improves the certainty with which solar particle capable of reaching aircraft are characterized

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-4
Parameter	c.2.a. Measurement Range – Flux, protons <100 MeV

Threshold	$5x10^{3}$ - $2x10^{9}$ m^{-2} s^{-1} $ster^{-1}$
Clarification	The parameter refers to the flux of ions with energies > 10 MeV. The maximum threshold flux is 4 times greater than the maximum flux observed by GOES during the last 25 years. The minimum is 5% of the threshold flux for a solar particle event, 10^{5} m^{-2} s^{-1} $ster^{-1}$, and provides for unambiguous event identification.
Objective	$5x10^{3}$ - $2x10^{9}$ m^{-2} s^{-1} $ster^{-1}$
Clarification	The objective is the same as the objective. The threshold range satisfies all operationally relevant needs.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-13
Parameter	c.2.b. Measurement Range – Flux, protons >100 MeV

Threshold	10^3 – 3×10^8 m^{-2} s^{-1} $ster^{-1}$
Clarification	Integral flux. The maximum >100 MeV flux is 6 times the estimated maximum flux for a solar particle event during the last 30 years. The minimum is 10% of the threshold flux for a >100 MeV solar particle event, 10^4 m^{-2} s^{-1} $ster^{-1}$, and provides for unambiguous event identification.
Objective	10^3 – 3×10^8 m^{-2} s^{-1} $ster^{-1}$
Clarification	The threshold range satisfies all operationally relevant needs.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-5
Parameter	c.3. Measurement Range - Flux, alphas

Threshold	N/A
Clarification	This is an objective parameter.
Objective	10^2 - 10^8 m^{-2} s^{-1} $ster^{-1}$
Clarification	Alpha particles, while fewer, are more damaging to semiconductors and to biological tissue. It is desirable to characterize the alpha particle component in a solar particle event.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-6
Parameter	c.4. Measurement Range – Sensor viewing angle

Threshold	0^o
Clarification	Sensor views outwards at 0º to the earth-center satellite vector . This insures that solar energetic particles incident at angles between 0º and 90º to the local magnetic field are detected at geographic - latitudes ≥30º
Objective	0^o
Clarification	The objective is the same as the threshold. A single “outward” pointing sensor view angle is all that is required.

EDR 40.8.14
Energetic Ions

Paragraph No.		40.8.14-14
Parameter		c.5. Measurement Range - Linear energy transfer (Heavy ions)
Threshold	1 – 50 MeV cm^2 mg^{-1}	
Clarification	Linear Energy Transfer is a measure of energy deposition in materials from radiation and is applicable to semi-conductor radiation damage assessment and biological tissue radiation dose	
Objective	0.1 – 100 MeV cm^2 mg^{-1}	
Clarification	Increased dynamic range in LET allows better assessments at both low and high levels of radiation exposure	

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-19	
Parameter	c.6. Measurement Range - Energy resolution	
Threshold	4 logarithmically spaced bands	
Clarification	The effects of energetic solar protons are dependent upon particle energy and fluxes, as a function of energy must be determined. This requirement is consistent with 40.8.13-14. The consistency comes about because the specification of 6 log spaced energy thresholds between 50 and 10,000 keV in 14.8.13-14 converts to a factor of about 2.9 between energy thresholds. The threshold of 4 energy bands between 10 and 400 MeV in 40.8.14-5 converts to an increment of 2.5. Three energy bands would have an increment of 3.4. NOAA POES uses 4 energy bands.	
Objective	5 logarithmically spaced bands	
Clarification	The increase to 5 energy bands is consistent with the objective of 400 MeV in 40.8.14-3	

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-8
Parameter	d.2.a. Measurement Precision – Flux, protons < 100 MeV

Threshold	Greater of {$5X10^{3}$ m^{-2} s^{-1} $ster^{-1}$, 5%}
Clarification	This refers to Poisson counting statistics and the effect of data compression.
Objective	Greater of {$5X10^{3}$ m^{-2} s^{-1} $ster^{-1}$,1%}
Clarification	This provides for more precise determination of variations in solar proton flux.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-15
Parameter	d.2.b. Measurement Precision – Flux, protons > 100 MeV
Threshold	Greater of {10^3 m^{-2} s^{-1} $ster^{-1}$, 10%}
Clarification	This refers to Poisson counting statistics and the effect of data compression.
Objective	Greater of {10^3 m^{-2} s^{-1} $ster^{-1}$, 2%}
Clarification	This provides for more precise determination of variations in solar proton flux.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-9
Parameter	d.3.a. Measurement Precision – FOV, protons <100 MeV

Threshold	<120º full angle
Clarification	For a sensor viewing radially outward, this insures that solar protons incident from above will be efficiently detected at all geographic latitudes ≥ 30º
Objective	<120º full angle
Clarification	The objective is the same as the threshold. There is no perceived operational benefit for extending the FOV beyond that specified in the threshold.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-20
Parameter	d.3.b. Measurement Precision – FOV, protons > 100 MeV

Threshold	≤360º full angle
Clarification	This reflects the great penetrating power of very energetic protons that gain access to sensors from all directions.
Objective	≤360º full angle
Clarification	The objective is the same as the threshold.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-11
Parameter	e.2.a. Measurement Accuracy – Flux, protons < 100 MeV

Threshold	max {$5X10^{3}$ m^{-2} s^{-1} $ster^{-1}$, 20%}
Clarification	This refers to preflight accuracy in the sensor calibration
Objective	max { $5X10^{3}$ m^{-2} s^{-1} $ster^{-1}$,10%}
Clarification	This provides for more accurate determination of particle flux

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-16
Parameter	e.2.b. Measurement Accuracy – Flux, protons > 100 MeV

Threshold	max {10^3 m^{-2} s^{-1} $ster^{-1}$, 20%}
Clarification	This refers to preflight accuracy in the sensor calibration
Objective	max {10^3 m^{-2} s^{-1} $ster^{-1}$, 15%}
Clarification	This provides for more accurate determination of particle flux

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-12
Parameter	e.3.a. Measurement Accuracy – FOV, protons < 100 MeV

Threshold	<12º
Clarification	This refers to the combined effects of sensor mounting accuracy and spacecraft stabilization. It is 10% of the sensor FoV.
Objective	<8º
Clarification	This provides for a more accurate determination of sensor viewing direction with respect to the local magnetic field.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-21
Parameter	e.3.b. Measurement Accuracy – FOV, protons > 100 MeV

Threshold	N/A (isotropic)
Clarification	For protons >100 MeV a 360º FOV is acceptable and accuracy in sensor mounting is not relevant.
Objective	N/A (isotropic)
Clarification	The objective is same as threshold.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-18
Parameter	g. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.14
Energetic Ions

Paragraph No.	40.8.14-22
Parameter	h. Measurement Uncertainty - Energy

Threshold	20%
Clarification	This refers to the combined effects of statistical uncertainties and uncertainties in the performance of the detector system (e.g. non-unique particle paths through absorbers, uncertainties in shielding, radiation degradation, etc)
Objective	10%
Clarification	Less uncertainty in knowledge of particle energy converts to a more reliable determination of particle energy distribution

EDR 40.8.16
Supra-thermal through Auroral Particles

Description: In-situ measurements of moderately energetic (< 50 keV) electrons and ions, primarily in the auroral regions. Measurement of the energy distribution of both precipitating and trapped charged particles within the specified energy range is required. Previous sensors of this type are the DMSP SSJ and POES TED series of detectors.

Usage: These measurements assist in satellite system anomaly analysis (surface charging), provide required quantitative input data to ionospheric and upper atmosphere models, and provide a physical measure of the level of auroral activity and the effects of that activity upon the ionosphere, atmosphere, communication and satellite systems.

EDR 40.8.16
Supra-thermal through Auroral Particles

		Threshold	Objective
40.8.16-1	a. Horizontal Reporting Interval	10 km	5 km
40.8.16-2	b. Horizontal Coverage	>30º latitude, N/S	>30º latitude, N/S
	c. Measurement Range (e & ions)		
40.8.16-3	1. Particle Energy	30 eV - 50 keV	30 eV - 50 keV
	2. Flux		
40.8.16-4	a. electrons	10^9 - 10^{14} m^{-2} s^{-1} $ster^{-1}$	10^9 - 10^{14} m^{-2} s^{-1} $ster^{-1}$
40.8.16-15	b. ions	10^9 - 10^{13} m^{-2} s^{-1} $ster^{-1}$	10^8 - 10^{13} m^{-2} s^{-1} $ster^{-1}$
40.8.16-5	3. Sensor viewing angles	0º & 90º (2 angles)	0º – 90º (multiple angles)
40.8.16-16	4. Particle energy resolution	24 log-periodic energy bands	32 log-periodic energy bands
	d. Measurement Precision		
40.8.16-6	1. Deleted		
40.8.16-7	2. Diff.directional energy flux	Max {10^9 m^{-2} s^{-1} $ster^{-1}$, 10%}	Max {10^8 m^{-2} s^{-1} $ster^{-1}$, 2%}
40.8.16-8	3. Sensor FOV	<15º	<15º

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EDR 40.8.16
Supra-thermal through Auroral Particles

continued

		Threshold	Objective
	e. Measurement Accuracy		
40.8.16-9	1. Pass Band Center Energy	2%	1%
40.8.16-10	2. Diff. Dir Energy Flux	Greater of {15%, 10^9 m^{-2} s^{-1} $ster^{-1}$}	Greater of {10%, 10^9 m^{-2} s^{-1} $ster^{-1}$}
40.8.16-11	3. Sensor Field-of-View	$<3^o$	$<3^o$
40.8.16-12	f. Measurement Uncert. – Energy	20%	15%
	g. Deleted		
40.8.16-13	1. Deleted		
40.8.16-14	2. Deleted		
40.8.16-17	h. Latency (Data Latency)	90 minutes	15 minutes

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-1
Parameter	a. Horizontal Reporting Interval

Threshold	10 km
Clarification	NOAA POES observations show the mean latitudinal extent of intense auroral particle precipitation events is of order 25 km. A 10 km reporting interval permits resolving this mean dimension.
Objective	5 km
Clarification	The distribution in latitude extent of intense auroral particle precipitation continues to increase to the 10 km spatial dimension that is the limit to the NOAA POES observations. The objective of 5 km reporting interval permits resolving such spatially narrow events.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-2
Parameter	b. Horizontal Coverage

Threshold	>30º Latitude, N/S
Clarification	This insures required observations are obtained during periods of extreme geophysical activity
Objective	>30º Latitude, N/S
Clarification	The objective is the same as the threshold. At the extreme levels of geomagnetic stress represented by the threshold lower latitudes maximum precautions should be taken. There is no operational benefit from extending the measurement of supra-thermal through auroral particles below the threshold.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-3
Parameter	c.1. Measurement Range - Particle Energy

Threshold	30 eV - 50 keV
Clarification	The lower particle energy limit of 30 eV represents the minimum that will affect the F-region ionosphere and it consistent with the minimum particle energy currently measured by the DMSP particle instrument. The upper particle energy limit of 50 keV is consistent with the low energy limit set in paragraph 40.8.13-2. Ion species discrimination is not required. It is assumed that electrons and ions shall be separately measured.
Objective	30 eV - 50 keV
Clarification	The objective is the same as the threshold.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-4
Parameter	c.2.a. Measurement Range – Flux, electrons
Threshold	$10^{9} – 10^{14}$ m^{-2} s^{-1} $ster^{-1}$
Clarification	This parameter refers to the differential directional energy flux of electrons. This is equivalent to a directional electron energy flux, when integrated over the full energy range 30 eV to 50 keV, ranging from 8×10^{-6} to 0.8 W m^{-2} $ster^{-1}$ and is consistent with EDR 40.8.2
Objective	$10^{9} – 10^{14}$ m^{-2} s^{-1} $ster^{-1}$
Clarification	The objective is the same as the threshold.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-12
Parameter	c.2.b. Measurement Range – Flux, ions

Threshold	$10^{9} – 10^{13}$ m^{-2} s^{-1} $ster^{-1}$
Clarification	This parameter refers to the differential directional energy flux of ions. The top end of the range for ions is slightly lower than for electrons since ion fluxes rarely exceed 10^{13}.
Objective	$10^{8} – 10^{13}$ m^{-2} s^{-1} $ster^{-1}$
Clarification	Low fluxes of ions can be useful in determining auroral boundaries.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-5
Parameter	c.3. Measurement Range - Sensor viewing angles

Threshold	0º& 90º (2 angles)
Clarification	0º refers to an outward looking sensor radially aligned (nominally) with the earth-satellite vector. The 90º Sensor Viewing Angle is perpendicular to the earth-satellite vector. Directional sensors viewing at these aspect angles will insure that both magnetically mirroring particles and particles within the atmospheric loss cone are separately observed at absolute geographic latitudes >35º
Objective	0º – 90º (multiple angles)
Clarification	The objective calls for additional sensor viewing angle sensitive to particles precipitating within the atmospheric loss cone at absolute geographic latitudes >35º. The additional sensor viewing angle would better determine the particle fluxes impacting the atmosphere allowing improved assessment of ionospheric and atmospheric consequences.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-13
Parameter	c.4. Measurement Range - Particle Energy Resolution

Threshold	24 log-periodic energy bands
Clarification	The effects of supra thermal and auroral particles on spacecraft systems and the upper atmosphere are dependent upon particle energy and fluxes as a function of energy must be determined. The threshold converts to an increment of 1.38 from one energy band to the next.
Objective	32 log-periodic energy bands
Clarification	Increased energy resolution and better definition of particle energy spectrum. The objective converts to an increment of 1.27 from one energy band to the next.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-7
Parameter	d.2. Measurement Precision - Differential-directional energy flux

Threshold	Greater of {10%, 10^9 m^{-2} s^{-1} $ster^{-1}$}
Clarification	This refers to Poisson counting statistics and the effect of data compression.
Objective	Greater of {2%, 10^8 m^{-2} s^{-1} $ster^{-1}$}
Clarification	The 10^8 m^{-2} s^{-1} $ster^{-1}$ refers to the minimum ion measurement. The 10^9 m^{-2} s^{-1} $ster^{-1}$ is sufficient electrons. The objective parameter provides for more precise determination of variations in auroral particle fluxes.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-8
Parameter	d.3. Measurement Precision - Sensor FOV

Threshold	<15º
Clarification	This parameter refers to the sensor full angle FOV in any direction. A narrow sensor FoV is required if unambiguous measurements are to be made at more than one direction within the atmospheric loss cone
Objective	<15º
Clarification	The objective is the same as the threshold. There is no operational benefit to reducing the required measurement precision in the sensor FOV.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-9
Parameter	e.1. Measurement Accuracy - Pass band center energy

Threshold	2%
Clarification	This refers to the accuracy to which the center energy of each energy band in EDR 40.8.16-12 is determined in flight. This value forbids a channel from overlapping the nominal energy range of a neighboring channel by more than roughly 10%.
Objective	1%
Clarification	Improved knowledge of the center energy of each energy band converts to improved determination of auroral particle fluxes. This value forbids channel overlap of more than roughly 5%.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-10
Parameter	e.2. Measurement Accuracy – Differential-directional energy flux

Threshold	Greater of {15%, 10^9 m^{-2} s^{-1} $ster^{-1}$}
Clarification	This refers to preflight accuracy in the sensor calibration and knowledge of the sensor geometric factor.
Objective	Greater of {10%, 10^9 m^{-2} s^{-1} $ster^{-1}$}
Clarification	The objective provides for more accurate determination of auroral particle absolute flux values.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-11
Parameter	e.3. Measurement Accuracy - Sensor FOV

Threshold	<3º
Clarification	This refers to the combined effects of sensor mounting accuracy and spacecraft stabilization. It is 20% of the sensor FoV set down in parameter 40.8.16-8.
Objective	<3º
Clarification	The objective is the same as the threshold. There is no perceived operational benefit from an improved measurement accuracy for the sensor FOV.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-12
Parameter	f. Measurement Uncertainty - Particle energy

Threshold	20%
Clarification	The threshold value of 20% refers to the center of each energy band as defined in paragraph 40.8.16-13, threshold. This refers to the combined effects of the width of the energy channels, statistical effects, the calibration of the detector system, and in-flight variations in the performance of the detector system.
Objective	15%
Clarification	The objective value of 15% refers to the center of each energy band as defined in paragraph 40.8.16-13, threshold. Less uncertainty in the knowledge of particle energy converts to a more reliable determination of auroral particle differential-directional energy flux.

EDR 40.8.16
Supra-thermal through Auroral Particles

Paragraph No.	40.8.16-15
Parameter	h. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage “store and dump” communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

EDR 40.8.18
Neutral Winds (P^3I)

Description: Neutral winds play a significant role in the dynamics of the upper thermosphere. Neutral winds have a significant effect on satellite drag and are a determining factor in the generation of equatorial scintillation in the ionosphere near dusk. Specification of neutral winds is also important to first-principles thermospheric models. The requirement is for measurements of the zonal and meridional components of the neutral wind.

Upper atmosphere winds can be measured from space using passive optical instruments (e.g., Fabry Perot Interferometers) that measure Doppler shifts in airglow emissions. These instruments are not part of the baseline payload and represent a significant increment with respect to cost and demands on satellite resources. Neutral winds is an objective EDR since the utility of wind measurements is uncertain, pending further study.

Usage: Neutral wind fields are of vital importance to assimilative ionosphere models and prediction systems. Additionally, neutral winds is an input into thermospheric first-principles models.

EDR 40.8.18
Neutral Winds (P^3I)

		Threshold	Objective
	a. Horizontal Cell Size	250 km	250 km
	b. Horizontal Reporting Interval	250 km	250 km
	c. Vertical Cell Size	15 km	15 km
	d. Vertical Reporting Interval	15 km	15 km
	e. Horizontal Coverage	Global	Global
	f. Vertical Coverage	90-500 km	90 to 500 km
	g. Measurement Range	0 to $\pm$1500 m s^{-1}	0 to $\pm$1500 m s^{-1}
	h. Measurement Uncertainty	Greater of {5%, 5 m s^{-1}}	Greater of {5%, 5 m s^{-1}}
	i. Latency (Data Latency)	90 minutes	15 minutes

Note: There are no specific TRD requirements for this Neutral Winds EDR – Pre-Planned Product Improvement. The above values were derived from section 4.1.6.8.10 (Neutral Winds) of the NPOESS Integrated Operational Requirements Document (IORD) II [draft], dated April 2001.

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.	N/A
Parameter	a. Horizontal Cell Size

Threshold	250 km
Clarification	This horizontal cell size is required as input into a global first-principles model to obtain neutral density to within 5% uncertainty.
Objective	250 km
Clarification	The objective is the same as threshold.

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.	N/A
Parameter	b. Horizontal Reporting Interval

Threshold	250 km
Clarification	This is the same as the Horizontal Cell Size (40.8.18-1) and ensures a spatial continuity in measurements from one cell to the next.
Objective	250 km
Clarification	The objective is the same as threshold.

EDR 40.8.18
Neutral Winds (P³I)

Paragraph No.	N/A
Parameter	c. Vertical Cell Size

Threshold	15 km
Clarification	This vertical cell size is required as input into a global first-principles model to obtain neutral density to within 5% uncertainty.
Objective	15 km
Clarification	The objective is the same as threshold.

EDR 40.8.18
Neutral Winds (P^{3}I)

Paragraph No.	N/A	
Parameter	d. Vertical Reporting Interval	
Threshold	15 km	
Clarification	This is the same as the Horizontal Cell Size (40.8.18-1) and ensures a spatial continuity in measurements from one cell to the next.	
Objective	15 km	
Clarification	The objective is the same as threshold.	

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.	N/A
Parameter	e. Horizontal Coverage

Threshold	Global
Clarification	The drag force is related to the velocity of the satellite (or debris) relative to the wind velocity. At high latitudes during disturbed conditions, winds can be a 20% effect relative to no-wind conditions. From 50 to 90^o latitude, the neutral winds effects are greater than the 5% uncertainty of the objective neutral density profile requirement.
Objective	Global
Clarification	The objective is the same as threshold.

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.	N/A
Parameter	f. Vertical Coverage

Threshold	90 - 500 km
Clarification	From 200 – 400 km altitude, neutral winds effects are greater than the 5% uncertainty of the objective neutral density profile requirement. The next generation ionosphere prediction models need winds from 90 – 500 km, the lower altitude being the most important.
Objective	90 to 500 km
Clarification	The objective is the same as threshold.

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.		N/A
Parameter		g. Measurement Range
Threshold	0 to ±1500 m s^{-1}	
Clarification	This range adequately covers the maximum winds recorded by the Dynamic Explorer satellite. However, a lower upper bound would provide useful data to support scintillation prediction in the low latitudes.	
Objective	0 to ±1500 m s^{-1}	
Clarification	The objective is the same as threshold.	

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.	N/A
Parameter	h. Measurement Uncertainty
Threshold	Greater of {5%, 5 m s^{-1}}
Clarification	Winds data is valuable for first-principles models that would be used to meet the 5% uncertainty requirement for neutral density profile.
Objective	Greater of {5%, 5 m s^{-1}}
Clarification	The objective is the same as threshold.

EDR 40.8.18
Neutral Winds (P^3I)

Paragraph No.	N/A
Parameter	i. Latency (Data Latency)

Threshold	90 minutes
Clarification	Most space weather products that use data from the polar-orbiting environmental satellites, DMSP and POES, are limited by a 101-minute orbital period and a heritage "store and dump" communications architecture. A data latency of this order is sufficient to provide a general level of situational awareness for global geophysical stress. A 90-minute data latency for NPOESS-era space environmental data is considered to be an acceptable threshold delay for supporting the quality and usefulness of current and future global space weather products in this category.
Objective	15 minutes
Clarification	Dynamic space weather phenomena, particularly mesoscale features at high latitudes, can vary on time scales of one hour to minutes. While, many current space weather products have a limited time response and are most useful in the context of a more slowly-varing response to global changes in geophysical stress (see above), there are exceptions. Among these are the current and emerging space weather products based on the modified K_p and Dst indices that are derived at a canence of 15 minutes from the USGS ground-based magnetometer network. Future users of NPOESS SESS data may require more localized and timely space environmental data than currently available from DMSP or POES. In order to satisfy user future needs for timely space weather information and to augment existing capabilities the data latency for the NPOESS SESS EDRs should have an objective value of 15 minutes.

SESS System Requirements Review

SESS Background

EDR Parameter Clarifications

EDR Category Designations

Notional Sensor Suite (H/W & S/W)

Summary

SESS EDR Categories and Rationales

EDR	Threshold	Objective
Auroral Boundary	II	A
Auroral Energy Deposition	II	B
Auroral Imagery	III	B
Electric Field	II	A
Electron Density Profile	II	A
Geomagnetic Field	II	A
In-situ Plasma Fluctuations	III	B
In-situ Plasma Temperature	III	B
Ionospheric Scintillation	III	B
Neutral Density Profile	II	B
Medium Energy Charged Particles	II	B
Energetic Ions	II	B
Supra-thermal to Auroral Energy Particles	II	B
Neutral Winds (P^3I)		B

SESS EDR Categories and Rationales

EDR 40.8.1 Auroral Boundary (Category II A) – The location of the auroral boundary is a key feature of the space environment. It is currently in operational use by both the DOC and the DOD. Identification of the poleward boundary would fully bound the region of particle precipitation, providing improved situational awareness for radar and HF communications systems.

SESS EDR Categories and Rationales

EDR 40.8.2 Auroral Energy Deposition (Category II B) - This EDR is assigned category B because achieving the objectives will result in an incremental reduction in the uncertainties in the ultimate products associated with the measurements. Of the requirements, the objectives in paragraph 40.8.2-1 are the most important.

SESS EDR Categories and Rationales

EDR 40.8.3 Auroral Imagery (Category III B) – Auroral imagery will be used by operational radar systems to determine in near-real time whether aurora structure is in the field of view of the radar. The objective observations of dim auroral features under all (including very quiet) conditions probably would not add value for supporting radars since the radar systems will not be impacted under geomagnetically quiet conditions. However, more timely refresh, per 40.8.3-7, would provide added value to radar operators. Auroral imagery can also be used to support numerous other EDRs.

SESS EDR Categories and Rationales

EDR 40.8.4 Electric Field (Category II A) – The electric field is a key Space Weather environmental parameter used by the DOC for global situational awareness and by the DOD as an essential input to magnetospheric and ionospheric models. The objectives for this EDR, which support low–latitude scintillation prediction, are an important future application for this EDR.

SESS EDR Categories and Rationales

EDR 40.8.5 Electron Density Profile (Category II A) - The Electron Density Profile is a key parameter for Space Weather. Consistently, this parameter has been given the highest priority in official DOD requirement and planning documents. The objective parameters for this EDR will bring about a substantial payoff in value added for several DoD systems; specifically, applications related to communication systems (ground-to-ground as well as ground-to-satellites), GPS navigation systems, missile warning systems and unmet requirements supporting National Program needs.

SESS EDR Categories and Rationales

EDR 40.8.6 Geomagnetic Field (Category II A) - While the threshold accuracy and precision should prove sufficient, the primary user would like the data to be as clean as possible. For this reason accuracy and precision (40.8.6-2 and -3) are identified as important objectives currently [*TBD*].

SESS EDR Categories and Rationales

EDR 40.8.9 In-situ Plasma Fluctuations (Category III B) - Scintillation effects on operational communications and navigation systems can be significant, but are also highly variable on a day-to-day basis. This makes knowledge/prediction of the presence of scintillation one of the most important SESS end-user priorities. While this EDR contributes to scintillation knowledge, the mapping of in-situ irregularities to lower altitudes is an area of research. However, objective requirements involving measurements under low-level scintillation conditions, while interesting from a long-term science perspective, would only minimally enhance operational utility.

SESS EDR Categories and Rationales

EDR 40.8.10 In-situ Plasma Temperatures (Category III B) - The ion and electron temperatures have clear traceability to user needs, and they are presently used as an input to the DOD operational model that calculates electron density profiles. Plasma temperatures are used in a number of Space Weather physics-based codes. However, these codes use empirical values when the data are not available -- in other words in-situ plasma temperatures are not key model parameters. Meeting the objective categories would provide an incremental improvement in the models and research codes.

SESS EDR Categories and Rationales

EDR 40.8.11 Ionospheric Scintillation (Category III B) - Although prediction / specification of scintillation effects on operational systems is a very important driver of NPOESS SESS requirements (driving Electron Density Profile, Electric Field, In-Situ Plasma Fluctuations, and Neutral Wind EDRs), ground-based observations of scintillation using signals from geosynchronous communications satellites are the primary source of this type of data. A signal source on NPOESS that would allow scintillation measurements would only add to this capability during the limited times that NPOESS is over a particular ground site.

SESS EDR Categories and Rationales

EDR 40.8.12 Neutral Density Profile (Category II B) – This EDR has clear traceability to documented user needs. The improvement in atmospheric density specification and prediction that would occur through use of NPOESS-like observations is currently being determined. Approaching the objectives is valuable to the long-term development of first-principles models of the thermosphere & ionosphere.

SESS EDR Categories and Rationales

EDR 40.8.13 Medium Energy Charged Particles (Category II B) - This EDR is assigned category B because the objectives set down represent the most extreme radiation conditions that would be encountered on relatively rare occasions.

SESS EDR Categories and Rationales

EDR 40.8.14 Energetic Ions (Category II B) - This EDR is assigned category B because the objectives, largely a reduction in the uncertainty of the absolute particle flux values, represent an incremental improvement in the quality of the products generated from the measurements.

SESS EDR Categories and Rationales

EDR 40.8.16 Supra-thermal through Auroral Energy Particles (Category II B) - Most user needs have been captured in the threshold column, limiting the benefits of improved performance.

SESS EDR Categories and Rationales

EDR 40.8.18 Neutral Wind (Category B) - Since this is a P^{3}I EDR, it has the lowest prioritization.

SESS System Requirements Review

- SESS Background
- EDR Parameter Clarifications
- EDR Category Designations
- Notional Sensor Suite (H/W & S/W)
- Summary

EDR Mapping to Notional Sensors

EDR	GPS Occultation	Radio Beacon	Ultraviolet Imager	RPA / Langmuir Probe	Driftmeter / Cold Ion Trap	Magnetometer	Electostatic Analyzer	Fabry Perot Interferometer	Solid State Detector
Auroral Boundary			P				P		
Auroral Energy Deposition			S				P		
Auroral Imagery			P					S	
Electric Field					P				
Electron Density Profile	P	S	S	S					
Geomagnetic Field						P			
In-situ Plasma Fluctuations					P				
In-situ Plasma Temperature				P					
Ionospheric Scintillation	S	P							
Neutral Density Profile			P						
Medium Energy Charged Particles									P
Energetic Ions									P
Supra-thermal to Auroral Energy Particles							P		
Neutral Winds (P^3I)								P	

P = Primary Sensor
S = Supporting Sensor

Notional SESS Sensors H/W Status

Not So Notional **GPS Occultation Sensor (GPSOS)** for EDR 40.8.5 (Electron Density Profile) and EDR 40.8.11 (Ionospheric Scintillation)

The GPSOS sensor is being developed by the IPO separately from the rest of the SESS instruments. The prime contractor for this sensor is the European company Saab-Ericson. The GPSOS is a special purpose GPS receiver designed to track most GPS satellites viewable from a low Earth orbiting platform using one of three antennas. A zenith viewing antenna is used primarily for navigation, but also provides overhead total electron content (TEC) observations to help meet the EDP EDR. Fore and aft antennas view the Earth's limb to measure changes in GPS signal properties as GPS satellite rise and set through the ionosphere. These antennas are designed for high gain in the region of the atmosphere near the Earth's surface (to support tropospheric observations), but are capable of measurements throughout the ionospheric altitude range up to the spacecraft altitude. The GPSOS measures GPS signal pseudorange, phase,and signal-to-noise ratio at both the L1 (1.575 GHz) and L2 (1.228 GHz) frequencies from up to 18 (TBD?) GPS satellites simultaneously. The L2 measurement is accomplished using a codeless signal processing technology that eliminates the need for knowledge of military decryption information (I.e., the Y-code). RF processing circuitry is required for each antenna to appropriately suppress other signal sources on the NPOESS spacecraft and avoid saturation of sensitive low noise amplifiers.

The GPSOS autonomously varies the rate at which observations are made depending on the NPOESS-GPS geometry for each GPS satellite. Zenith antenna measurements are obtained at the lowest cadence (nominally 0.1 Hz, but selectable). When a satellite drops below the local horizon and begins to be occulted by the Earth's ionosphere, the measurement rate is increased to 1-10 Hz to obtain finer detail concerning the ionosphere's vertical structure. Similar higher rate observations are made for rising GPS occultations, for which signals are generally acquired before the tangent altitude reaches the bottom of the ionosphere (~100 km). Each satellite track provides slant path TEC for ingestion by an assimilative ionospheric model. Occultation measurements within 45-60 degrees of the satellite velocity vector may be inverted to produce EDPs. The GPSOS limb antennas are focused on this region, but some measurements at larger azimuth angles are made as well. These are only useful as a slant path TEC specification. Measurements at rates up to 100 Hz may also be made. These highest rate measurements can be used on the ground to calculate amplitude, and possibly phase scintillation parameters along the GPS satellite links, particularly for the stronger L1 signal.

Past heritage relevant to the occultation concept include sensors on the MicroLab-I (1995), Orsted (1999), SunSat (1999), CHAMP (2000), and Sac-C (2000) satellites. Additional flights of sensors in this line, originally develop by JPL, are also planned. The flight of GPSOS on NPOESS will be preceded by flight of the GRAS instrument, also developed by Saab-Ericson, and very similar to GPSOS, on a European weather satellite.

Notional SESS Sensors H/W Status

Notional **Radio Beacon** for EDR 40.8.5 (Electron Density Profile) and EDR 40.8.11 (Ionospheric Scintillation)

The notional radio beacon radiates ~1 watt each at 150, 400, and 1067 MHz using a single, deployable, multi-frequency antenna on the nadir, or possible side, surface of the NPOESS spacecraft. These three signals are derived from a single clock, stable to 1 part in 10^7. EMI filters are used as needed to avoid radiation of undesired harmonics of the clock frequency. The transmitted signals are circularly polarized, although linear polarization would be acceptable as well. The radio beacon is either on or off, and produces no telemetry. Environmental data associated with the beacon is obtained through a network of fixed and mobile ground sites, such as an expanded version of AFRL's SCINDA system (currently consisting of 6 receivers in the equatorial and auroral regions). The ground receivers are capable of measuring both amplitude and phase scintillations, and slant path total electron content. The latter can be used as input to an assimilative model or, if chains of multiple beacon receivers are present, to obtain detailed tomographic determinations of ionospheric densities in a particular region of the globe. Data from other NPOESS SES sensors, particularly the limb sensors (GPSOS and/or the UV Imager) may be used in the tomographic analysis to improve end product accuracy.

Phase coherent dual-frequency (150/400 MHz) beacons have a strongly established heritage and a long history of use. In particular, they have been flown on the US Navy Navigation Satellite System (NNSS) since 1964. Currently over twenty such beacons are in use on US OSCAR, RADCAL, GEOSAT Follow-On, ARGOS, and DMSP/F15 satellites. Foreign missions using such beacons include the Russian COSMOS and TSIKADA satellites, the Japanese NADEZHDA satellites and, most recently, the British STRV-1D satellite. Multi-frequency beacons that transmitted up to 10 phase coherent frequencies between 138 and 2900 MHz were used on the DNA-sponsored Polar Bear, HILAT, and WideBand satellites in the mid 1970's and the 1980's.

Notional SESS Sensors H/W Status

Notional **Ultraviolet Imager** for EDR 40.8.1 (Auroral Boundary), EDR 40.8.2 (Auroral Energy Deposition), EDR 40.8.3 (Auroral Imagery), EDR 40.8.5 (Electron Density Profile), and EDR 40.8.12 (Neutral Density Profile)

The concept of using atmospheric emissions in the extreme (EUV) and far ultraviolet (FUV) portions of the Earth's dayglow and nightglow spectrum to infer thermospheric properties is well established in the scientific community. However, operational sensors of this type are only just about to fly (i.e., the SSULI and SSUSI sensors on DMSP F16). Information on the utility, accuracy, and potential sensor improvements will become available over the next several years as these new operational sensors come on line and associated ground processing codes are validated. It should be noted that the F16 near-terminator orbit is a particularly stressing environment for UV algorithms that are different in the day and night, so that the full operational benefit may not be clear until after the launch of F17 in ~2003). In addition to the DMSP sensors, STP's ARGOS (02/99 launch) and NASA's TIMED (~04/01 launch) satellites have flown or will fly the LORAAS and GUVI sensors, which are very similar to SSULI and SSUSI, respectively.

The notional EUV/FUV sensor(s) will be capable of viewing both limb and disk geometries. Disk viewing is required to provide broad-area coverage necessary for determining auroral boundaries and morphology, whereas limb viewing is required for the detailed vertical profile information associated with the electron and neutral density EDRs. Some ionospheric information, with significantly less vertical resolution, is also available from the disk viewing geometry. The EUV/FUV sensor(s) will need to measure various emissions from various parts of the Earth's atmosphere. In the auroral zones, the sensor(s) will measure emissions or emission bands that provide information about the mean energy and flux of precipitating particles (e.g., the 135.6 nm and LBH emissions used by SSUSI). On the nightside and the dayside, emissions associated with the ionosphere (e.g., 83.4, 91.1, 135.6) will be measured. Also, dayside observations of features providing information on the neutral atmosphere will be measured on both the limb and disk to provide NDPs as well as broad-area composition information useful to multi-sensor data fusion algorithms and as input to advanced ionospheric models.

Because of the numerous features to be observed, it is likely that some form of spectrographic imager will be employed in which a 2-dimensional detector resolves spatial information in one direction and spectral information in the other. A mechanical scan mirror may be required to obtain disk imagery at multiple wavelengths, as is done for the SSUSI sensor. However, imaging photometers associated with specific spectral features can not be ruled out as a potential partial solution. If available, sufficient telemetry bandwidth should be provided for all spectral information.

Existing ground processing software associated with SSUSI and SSULI will evolve and be enhanced to provide improved ionospheric retrievals through multiple limb scan inversions and/or multi-sensor data fusion.

Notional SESS Sensors H/W Status

Notional **RPA/Langmuir Probe** and **Driftmeter/Cold Ion Trap for** EDR 40.8.4 (Electric Field), 40.8.5 (Electron Density Profile), EDR 40.8.9 (In-situ Plasma Fluctuations) and EDR 40.8.11 (In-situ Plasma Temperature)

The Special Sensor for Ions, Electron, and Scintillation (SSIES) is the heritage DMSP sensor that is related to the indicated EDRs. The purpose of the SSIES is to detect and characterize the ambient ionospheric plasma at an altitude of ~840 km from a spacecraft that is traveling at 7.44 km/s. The SSIES consists of the following sensors elements; 1) ion retarding potential analyzer (RPA), 2) ion driftmeter (DM), 3) total ion trap (SM), a spherical electron sensor (EP). The EP measures the electron temperature and density; the RPA measures ion composition, density, temperature, and the ion-drift velocity component in the ram direction; the DM measures the ion-drift velocity components normal to the satellite velocity; and the SM measures density variations in the local plasma. The electric field is derived from the measurement of ion velocity after removing the effects of satellite motion and Earth rotation. All of the ion sensors are planar, electrostatic analyzers, often referred to as Faraday cups. The planar geometry is appropriate for measuring thermal ions since the spacecraft speed is supersonic with respect to the ions. For the electrons, the spacecraft speed is subsonic and a spherical geometry is more appropriate for collecting and measuring them. A detailed technical description of the SSIES is contained in the report by Rich [1994].

The operational ground software used for processing the SSIES sensor data is the APGA code currently installed at the 55 Space Weather Squadron (55th SWxS) at Shriever AFB. This code will be ported to Offutt AFB as part of the move of the 55 SWxS to the Space Weather Operations Center (SWOC) in the Air Force Weather Agency (AFWA). APGA is the processing code that converts the sensor data records into useful scientific parameters at a level commensurate with NPOESS EDRs.

Rich, F.J. Users guide for the Topside Ionospheric Plasma Monitor (SSIES, SSIES-2, amd SSIES-3) on Spacecraft of the Defense Meteorological Satellite Program (DMSP), PL-TR-94-2187, 76 pp, 1994.

Notional SESS Sensors H/W Status

Notional Vector **Magnetometer** for EDR 40.8.6 (Geomagnetic Field)

Vector magnetometers have flown on many spacecraft (including DMSP) and much is known about their performance. The heritage operational DMSP SSM is a triaxial fluxgate magnetometer that utilizes a ring core geometry. The parameters measured by the SSM are the three components of the magnetic field vector. The range is from +65535 to -65535 nT for each axis, with a one-bit resolution of 2 nT.

An important element in the design of the SSM is the feedback coil which nulls the ambient field within +/- 2000 nT and the sensor core itself. Misalignment and temperature instability of the sensor core can be a significant source of error. The SSM performance is also critically dependent on the design of the spacecraft. Much of the success of the magnetometer-spacecraft system depends on limiting the spacecraft generated magnetic noise. For this reason the SSM is mounted on a boom and the spacecraft noise minimized by twisting all wiring in the spacecraft, using nonmagnetic and non-conducting (electrical and thermal) materials, etc. A scalar magnetometer on NPOESS may also be required in order to maintain calibration of the vector magnetometer. In order to minimize the observational uncertainty in each component of the magnetic field vector, the pointing of the magnetometer will have to be known precisely, including the effect of any boom flexing.

The operational ground software for processing the DMSP SSM data is APSM. APSM generates a series of magnetic field measurements in the form of three orthogonal field vectors with satellite position information. Currently, the SSM data is not processed at the 55th Space Weather Squadron, Shriever AFB. However, the APSM code is currently being installed and the SSM data will be processed at the Space Weather Operations Center (SWOC), Offutt AFB following IOC in early 2001.

Notional SESS Sensors H/W Status

Notional **Electostatic Analyzer** for EDR 40.8.1 (Auroral Boundary), EDR 40.8.2 (Auroral Energy Deposition), and EDR 40.8.16 (Supra-thermal through Auroral Particles)

The heritage operational sensors for monitoring auroral charged particles in an NPOESS-tyoe orbit are the Total Energy Detector (TED) for POES and the Special Sensor Electron and Ion Spectrometer (SSJ) for DMSP. Both sensors monitor the energy fluxes carried into the atmosphere by electrons and positive ions within an energy range from several 10'e of eV to several 10's of keV. The TED and the current generation for the SSJ, the SSJ/4, utilize cylindrical, curved-plate electrostatic analyzer geometries to select (by impressing a variable voltage between the analyzer plates) the species and energy of those particles that are permitted to reach the detector (channelton). The pitch angle responses for the TED and the SSJ/4 differ in that the TED samples two pitch angles; one viewing radially outward from Earth and the other viewing at 30^{o} to the first, whereas the SSJ/4 has a single FOV oriented radially outward. A new generation SSJ, the SSJ/5, utilizes a 270^{o} spherical geometry and a microchannel plate (MCP) detector to improve the picth-angle sampling of the detector. The SSJ/5 has a 90^{o} FOV divided into 6 adjacent sectors. With one sector aligned to the local magnetic field, the SSJ/5 provides full pitch angle information over the upper hemisphere for precipitating charged particles.

Ground processing for the TED combines the ion and electron data over the two sampling angles to obtain the total power flux carried into the atmosphere by auroral particles. The TED data is processed at the NOAA Space Environment Center (SEC). Similarly, data processing for the SSJ uses operational ground S/W at the 55th Space Weather Squadron (current), Shriever AFB, and at the Space Weather Operations Center (IOC in early 2001), Offutt AFB. The SSJ operational S/W consists of the following codes; APDA (Process SSJ Sensor Data) , the APEA (Locate SSJ Auroral Boundary) , the APFA (Compute SSJ Auroral Summary), and the APYA (Calculate SSJ Energies and Fluxes).

Notional SESS Sensors
H/W Status

Notional **Fabry-Perot Interferometer** for EDR 40.8.18 (Neutral Winds)

At present, there are no Fabry-Perot sensors in operational use. This write-up contains general information only.

The Fabry-Perot nterferometer is a high resolution, high throughput optical spectrometer that works on the principle of constructive interference[1]. The high throughput and high resolution are dependent parameters, and optimization of these must be performed to determine the best system[2]. The resolution can be defined in terms of finesses, where a finesse (F) is a factor given to quantify the performance of a Fabry-Perot interferometer[3]. A higher finesse corresponds to a higher resolution. A finesse may be degraded by a number of factors including mirror reflectivity, mirror surface quality, detector broadening (the vibrational and thermal stability of the interferometer) and instrument defects.

The Fabry-Perot interferometer has been used successfully on several spacecraft missions, including the Dynamics Explorer 2 (DE2) satellite and the Upper Atmospheric Research Satellite (UARS). The interferometer will be flown on the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) satellite in the first quarter of 2001.

[1] Optical Instrumentation Technology Branch homepage, NASA LERC.

[2] UARS High Resolution Doppler Imager (HRDI) Instrument Design web page.

[3] B. Samoriski, *Fabry Perot Interferometers Theory*, Burleigh Industries.

Notional SESS Sensors H/W Status

Notional **Solid State Detector** for EDR 40.8.13 (Medium Energy Charged Particles)

At the present time charged particle measurements over the range 50 keV to 10 MeV are obtained from a suite of multi-element, solid-state detector telescopes in the NOAA/POES SEM-2. A magnet is used to separate electrons from ions and an absorbing foil is used to minimize proton response in the electron telescopes. Directional sensitivity is obtained by means of entrance aperture structures. Particle energy discrimination is obtained primarily through electronic pulse height analysis although energy loss per unit path length in a detector plays a secondary role in the discrimination. These detectors are improved versions of instruments first included in the ITOS series of spacecraft in the late 1960's, largely to support the manned space flight program. Similar detector systems are planned for future GOES satellite SEM's.

While the basic design is well proven and has a long heritage, there are some areas for improvement (challenges). It would be helpful if the electron detector telescopes had less sensitivity to energetic protons that may gain access to the detector. Occasionally pulse pile-up will impact the interpretation of data during intense auroral events, especially from the electron detector telescope. Potentially the most important improvement would be a mitigation of radiation damage effects that are particularly apparent in the proton detectors after several years operation. Such mitigation might take the form of in-flight adjustable detector bias voltages, adjustable amplifier integration times, or a method of ascertaining the degree of radiation degradation through a form of in-flight calibration system.

The software for handling data from such sensors currently exists in well-proven, operational forms.

Notional SESS Sensors H/W Status

Notional **Solid State Detector** for EDR 40.8.14 (Energetic Ions)

At the present time energetic proton measurements at energies between 10 MeV and >300 MeV are obtained from a suite of "omni-directional" solid-state detectors in the NOAA/POES SEM-2. Particle species and particle energy discrimination is obtained by the use of "moderators", metal covers of various thicknesses and materials over the solid state detector. Broad angular discrimination is obtained through the design of moderator structure. These sensors have been included in the GOES SEM since the early 1970's and in the POES SEM since 1978.

While the basic design is well proven and has a long heritage, there are some areas for improvement (challenges). Both the particle energy and angular discrimination from these detectors tends to be ill-defined because of the wide spread in particle path-lengths through the moderator and it would be "nice" if this discrimination could be sharpened. These sensors, especially at the lower energies, respond to very high energy electrons and to the Bremsstrahlung those electrons produce. Methods of reducing the sensitivity to energetic electrons would be of benefit.

The software for handling data from such sensors currently exists in well-proven, operationa forms. The use of models in order to extrapolate the energetic ion measurements at a given location and obtain a global assessment would be a valuable addition to current capabilities.

The objective for obtaining information about alpha particles could be partially satisfied by a sensor similar to the HEPAD (High Energy Proton and Alpha Detector) that is currently flown on GOES (the sensor was also included in two of the SEM-1 packages before being assigned to GOES.) This is a rather complex instrument involving both solid-state detectors and a photomultiplier tube. There may be more advanced designs for discriminating alpha particles from protons, but I am not aware of them.

SESS System
Requirements Review

SESS Background

EDR Parameter Clarifications

EDR Category Designations

Notional Sensor Suite (H/W & S/W)

Summary

Summary

- The GAT provided an “SRR” to assist the IPO in the development of the SESS
- Clarifications were made for each of the parameters associated with the NPOESS space environmental EDRs
- Some updates to the TRD specifications and to the IOR-1A were recommended and subsequently approved
- The GAT welcomes comments by the IPO and by interested contractors, as appropriate, on the contents of this briefing